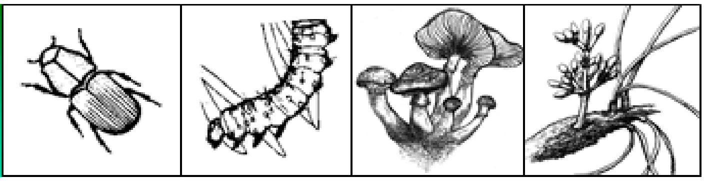
Forest Health Protection



19-05 ***April, 2019***

Mid-level Summary of Mountain Pine Beetle Infestations and Management throughout the Northern Region from 1909-1945

Jessica L. Jenne[1] and Joel M. Egan[2]

[1] Biological Science Technician, Forest Health Protection, Missoula, Montana
[2] Supervisory Entomologist, Forest Health Protection, Missoula, Montana

Executive Summary

Severe and widespread forest disturbance caused by the mountain pine beetle (*Dendroctonus ponderosae* Hopkins, MPB) occurred throughout the USDA Forest Service Northern Region from 1909-1945. Locations supporting MPB activity were reconstructed using geospatial information technologies and information summarized from nearly 1,690 pages of historical reports published in 80 technical reports and scientific journals. Reports were written primarily by Forest Entomologists from the USDA Bureau of Entomology and Plant Quarantine, Forest Insect Investigations Unit.

Overall, 2.9 million acres composed of lodgepole, whitebark, and western white pines were impacted. Ponderosa pine host were impacted less and only constituted 1% of the MPB areas mapped. Direct control techniques were widely implemented across National Forest/Park and private lands to manage MPB outbreaks and protect uninfested forests. A total of 10.9 million dollars (inflation-adjusted to 2018 value) were allocated to implement direct control projects. This management was often successful in small, localized areas and ineffective where infestations were expansive.

This report is a mid-level summary of historic mountain pine beetle infestation occurrence, impact, and management that occurred within historic National Forests and National Parks. Our goal was to summarize infestation dynamics and management that occurred during this MPB outbreak period to inform modern pest management strategies.

Data compiled for this report, including geospatial data containing references to site-specific historic reports, and digital scans of historic documents used can be accessed through Forest Service intranet by clicking here or contacting joel.egan@usda.gov.

Treatment crew peeling beetle-infested western white pines in northern Idaho (Rust 1930, p. 36)

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Introduction

Mountain pine beetles (*Dendroctonus ponderosae* Hopkins, MPB), also historically called *Dendroctonus monticola*, are native insects found throughout the range of pine forests within the Northern Region (R1) of the U.S. Forest Service (USFS) (Stock et al. 1984, pg.760). MPB attacks and colonizes *Pinus* species to obtain nutritional resources and provide for reproductive habitat (Elkin and Rein 2005). MPB have co-evolved with multiple hosts, including lodgepole pine (*Pinus contorta*); whitebark pine (*Pinus albicaulis*); western white pine (*Pinus monticola*); ponderosa pine (*Pinus ponderosa*); and limber pine (*Pinus flexilis*), with validation of severe and widespread outbreaks being documented since the Jurassic age (Brunelle et al. 2008). While evidence of outbreak occurrences goes back millennia, historical synthesis of outbreak extents, severity, progression, species impacted, and anthropogenic management techniques are rare.

R1 has had multiple severe and widespread MPB outbreaks within the past century. The outbreaks that occurred from 1971-1989 and 1999-2015 were monitored through annual Forest Health Protection aerial detection surveys. An l outbreak also occurred during the early 20th century; however, systematic monitoring did not occur prior to the 1960s. While quantitative data of the MPB event that occurred in the early 1900s is not available, professional entomologists first with the Bureau of Entomology from 1904-1934, and later with the Bureau of Entomology and Plant Quarantine's Division of Forest Insects from 1934-1949, qualitatively chronicled outbreak dynamics and historic direct control efforts in extensive detail (Evenden 1931; Evenden 1934; Evenden 1936-1943; Evenden 1944; Evenden 1946; National Archive

The goal of this report was to synthesize pertinent details of the early 20th century MPB event and documenting historical infestation dynamics at a Forest-level using qualitative Forest Health Monitoring reconstruction techniques. Specifically, our objectives were to summarize the occurrence, impact, spread, and management associated with elevated MPB pest activity from 1909-1945.

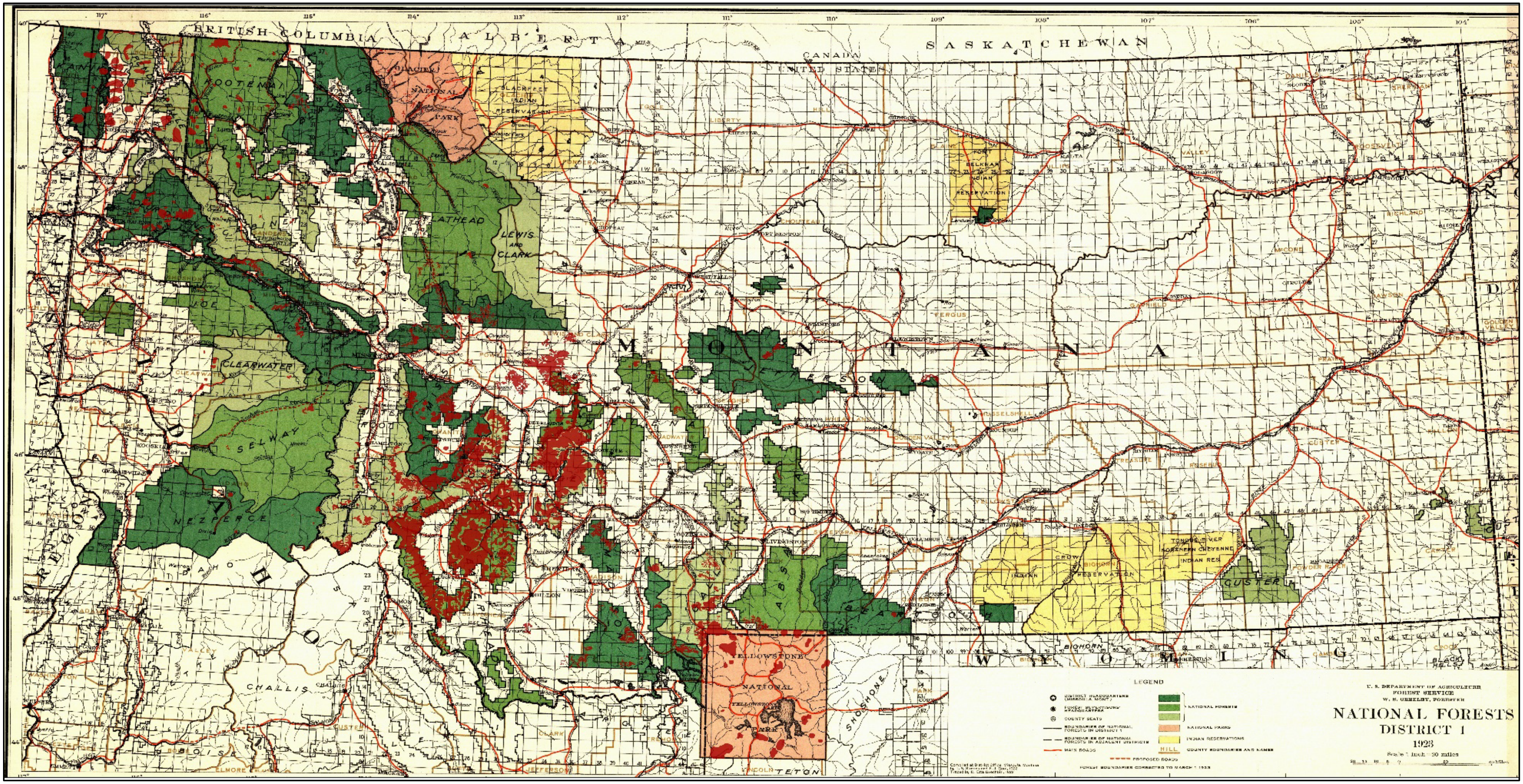
Methods for Mid-Level Geospatial Reconstructions

Spatial reconstruction of areas impacted by MPB in the early 20th century occurred following review and mining of spatially explicit data from 1,685 pages within 83 reports primarily written by USDA Bureau of Division of Forest Insect Investigation staff. Spatial information was recorded from detailed verbal descriptions of mortality locations and often from accompanying hand-drawn maps created to depict MPB survey results.

Spatial information for infested locations were recorded within a database populated with over 450 records documenting pertinent outbreak attributes including: pine species impacted, temporal period of outbreak occurrence, historic forest location, and each reference document with page numbers. Records were subsequently used to sketch outbreak perimeters on large maps utilizing drainage names/locations with converging lines of evidence from cross-referenced reports covering the same areas during different years. Sketched outbreak perimeters were subsequently geospatially digitized within ArcGIS v10.3 (ESRI 2008) where a presence/absence geospatial layer indicated forest distribution **(**Krist et al. 2014)**.**

Figure 1. Map of mountain pine beetle infestations throughout Northern Region Administrative Units from 1909-1945

Note: Areas mapped with MPB infestations are delineated in red and overlay a 1923-vintage Administration Unit map



BRITISH COLUMBIA
ALBERTA
SASKATCHEWAN
CANADA
UNITED STATES
MONTANA
IDAHO
WYOMING
OREGON
KOOTENAI
FLATHEAD
LEWIS AND CLARK
CLEARWATER
SELWAY
NEZPERCE
CHALLIS
GLACIER NATIONAL PARK
BLACKFEET INDIAN RESERVATION
FORT BELKNAP INDIAN RESERVATION
CROW INDIAN RESERVATION
TONGUE RIVER NORTHERN CHEYENNE INDIAN RES.
CUSTER
YELLOWSTONE NATIONAL PARK
SHOSHONE
TETON
LEGEND
DISTRICT HEADQUARTERS (MISSOULA, MONT.)
FOREST SUPERVISORS' HEADQUARTERS
COUNTY SEATS
BOUNDARIES OF NATIONAL FORESTS IN DISTRICT 1
BOUNDARIES OF NATIONAL FORESTS IN ADJACENT DISTRICTS
MAIN ROADS
PROPOSED ROADS
NATIONAL FORESTS
NATIONAL PARKS
INDIAN RESERVATIONS
HILL
COUNTY BOUNDARIES AND NAMES
FOREST BOUNDARIES CORRECTED TO MARCH 1 1923
U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
W. B. GREELEY, FORESTER
NATIONAL FORESTS
DISTRICT 1
1923
Scale 1 inch = 30 miles

This reconstruction method was purposely conservative and only led to final geospatial rendering of MPB outbreak locations where strong evidence existed. While available historic documents were utilized for this effort, it should be noted that minor infestations in localized areas may not be represented in this spatial reconstruction if they were not documented in historic reports.

A partial validation of reconstructed MPB outbreak location and extent occurred by comparing total area impacted reported for the National Forests surrounding Yellowstone NP with the final geospatial reconstructed area mapped with this project. Findings indicate that the 2.0 million acres of spatially reconstructed MPB-impacted area were similar to the 2.2 million acres reported within historical reports (Evenden 1944, p. 14). The small deviation between the two was potentially due to the vague definition of geographic area included for the area total within Evenden (1944).

I. Mountain Pine Beetle Impact and Occurrence throughout the Northern Region from 1909-1945

Spatial Extent of Outbreaks Reconstructed

The MPB outbreak event from 1909-1945 was reconstructed across 2.9 million acres of forested area throughout the twenty three National Forests of the U.S. Forest Service's Northern Region (R1) (Figure 1). Areas in both Glacier and Yellowstone National Parks, as well as some private ownerships, also had outbreaks (Evenden 1931; Evenden 1934; Evenden 1936-1943; Evenden 1946). These National Forest Administrative Unit boundaries and names changed substantially throughout the 20th and early 21st centuries. As such, all MPB outbreak information included in this report reflect the historic, 1923-vintage R1 Administrative Units (Figure 1). Significant outbreak details, as well as historic Administrative Unit boundary changes for each R1 National Forest and National Park are outlined in detail within the Section III, Forest-Level Summaries portion of this report.

Outbreak Severity across Pine Species Impacted

All pine host species present within the National Forests and National Parks within the Northern Region were impacted during the 1909-1945 MPB outbreak period (Table 1). Lodgepole pine was impacted the most with high-severity infestations occurring across the Region, especially where contiguous tracts of susceptible forest occurred. Whitebark and western white pine species were also infested during high-severity outbreaks; however, susceptible host distributions were often limited to isolated areas. A limited number of outbreaks were documented within ponderosa and limber pine species at mixed-severities (Evenden 1931, Evenden 1934, Evenden 1936-1943, Evenden 1946, Evenden 1948).

Lodgepole pine forest infestations were substantial in National Forests within central Montana (Figure 1; Table 1). Of all Administrative Units, the Beaverhead National Forest experienced the most severe and widespread MPB outbreak. Reports described over 50 million trees dying from 1927-1936 (Figure 2; Evenden & Gibson 1940, p. 273). During the latter portion of this outbreak, secondary bark beetles, primarily twig beetles (*Pityogenes knechteli* Swaine), also contributed to lodgepole pine mortality, particularly in small-diameter trees (Figure 2). In 1934, this prolonged infestation event prompted Entomologist James Evenden to write:

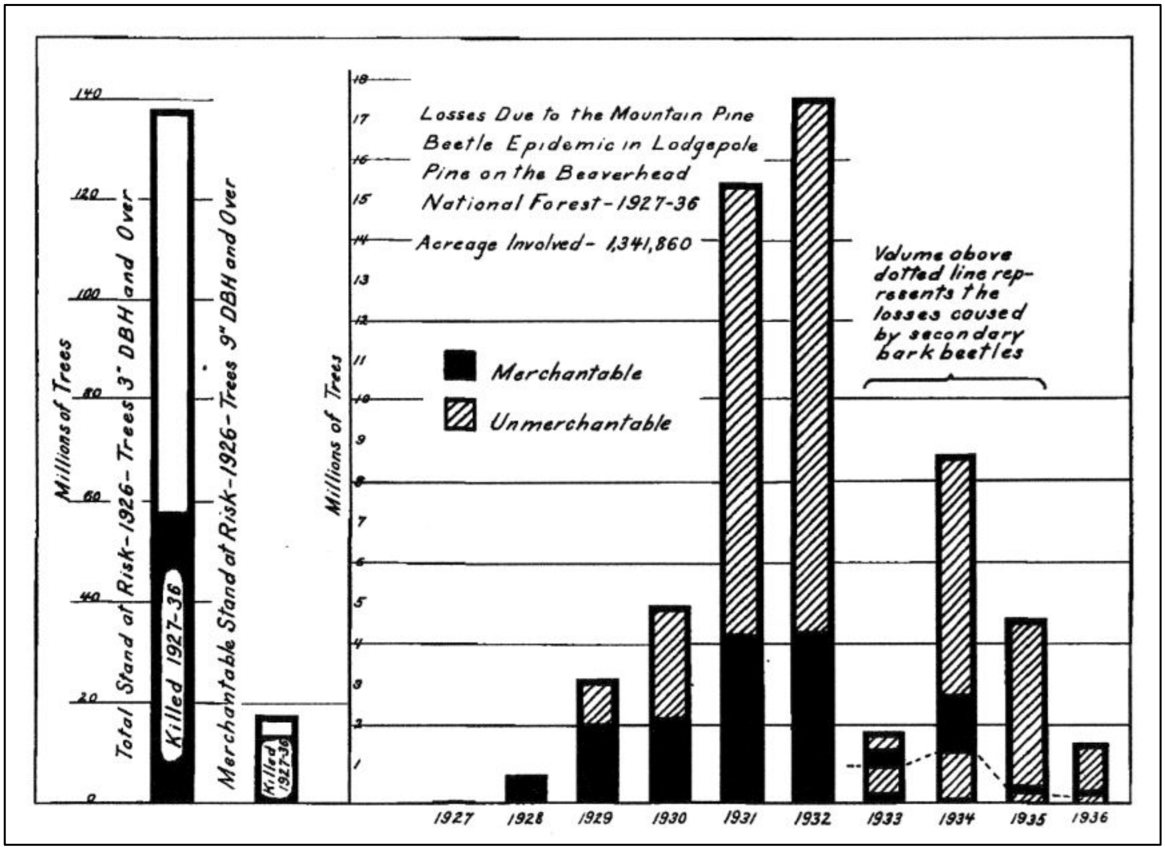
Table 1. Mountain pine beetle infested area by host and Administrative Unit

> *"What effect such an epidemic will have upon the timber stands in question is difficult to depict, and reference can only be made to the devastation which has occurred on the Montana and central Idaho forests, where on large areas 75% of all trees of 6" or more in diameter have been killed"*
> (Evenden 1934a, p. 17).

National Forest (NF) or National Park (NP)	Total Infested Area (ac)	Primary Host Impacted	Total Infested Area of Primary Host (ac)
Absaroka NF	18,671	whitebark pine	16,654
Beartooth NF	2,861	lodgepole pine	2,861
Beaverhead NF	845,195	lodgepole pine	830,787
Bitterroot NF	132,014	lodgepole pine	129,000
Blackfeet NF	18,166	lodgepole pine	12,510
Cabinet NF	4,758	western white pine	3,394
Clearwater NF	13,915	western white pine	11,054
Coeur d'Alene NF	70,278	western white pine	70,278
Deerlodge NF	512,508	lodgepole pine	512,508
Flathead NF	23,549	lodgepole pine	14,717
Gallatin NF	104,787	whitebark pine	58,533
Glacier NP	16,048	lodgepole pine	11,429
Helena NF	291,247	lodgepole pine	273,592
Jefferson NF	20,422	ponderosa pine	12,427
Kaniksu NF*	184,761	western white pine	184,761
Kootenai NF	65,721	western white pine	43,931
Lewis & Clark NF	4,344	ponderosa pine	4,344
Lolo NF	43,082	lodgepole pine	33,422
Madison NF	55,031	lodgepole pine	40,092
Missoula NF	267,418	lodgepole pine	267,418
Nez Perce NF	9,658	lodgepole pine	9,658
Selway NF	6,399	lodgepole pine	6,399
St. Joe NF	4,721	western white pine	4,721
Yellowstone NP	187,782	whitebark pine	154,441

***Due to administration changes that occurred during the outbreak period, the Kaniksu National Forest includes the acreage infested in Pend O'reille National Forest.**

Figure 2. Annual losses in lodgepole pine on the Beaverhead National Forest from 1927-1936
Source: Evenden & Gibson 1940, Journal of Forestry, Figure 2, p. 273



Severe outbreaks also occurred on the Bitterroot, Deerlodge, Helena, and Missoula National Forests where pure composition forested areas succumbed to heavy losses of lodgepole pine. Surveyors documented mountainsides of uninterrupted red trees and infestations that were greater than 1000 acres in size. The Missoula National Forest outbreak was so extensive in 1920 that Supervisor White wrote:

> *"We believe it is safe to say that insects are responsible for greater losses of timber during the last 11 years in the Blackfoot River watershed than fire"* (Evenden 1944, p. 5,7).

In the southeastern National Forests of R1, managers documented extensive MPB outbreaks throughout high-elevation whitebark forests that sustained severe mortality levels (Evenden 1937, p. 11). The Supervisor of Absaroka National Forest reported:

> *"Though the infestation is spreading at a slower rate than in the past, clumps of red-tops are showing each year in previously uninfested areas and [I believe] that even with this reduction all whitebark pine trees above 4" will be killed"* (Evenden 1937, p. 7).

Yellowstone National Park surveys reported infestations in nearly all whitebark pine stands where the majority of the susceptible, mature whitebark pines were killed (Furniss & Renkin 2003, p. 207).

Western white pine was an important component of the Northern Region's northwestern National Forests. Officials described ample declines in this timber species that was preferred for its economic value and utility. Road construction appeared to influence beetle numbers in western white pine on the Clearwater, Lolo, and Coeur d'Alene National Forests. Reports indicated MPB infestations within pines injured from site deterioration, dynamite-use, root excavation, scorching, choker injury, bole covering, and slash pile proximity from road-building efforts (Bedard 1939, p. 3-9).

Overall, Coeur d'Alene National Forest chronicled an annual loss of nine million board feet, nearly 200,000 mature western white pine from 1929-1939. The Kootenai National Forest reported comparable losses of western white pines due to MPB-infestation. Even low mortality rates in some locations were of concern to resource managers as mature western white pines were scarce throughout some landscapes due to harvest operations that targeted this timber species prior to the MPB outbreak period (Evenden 1934, p. 5; Evenden 1940, p. 6).

Progression and Duration of Mountain Pine Beetle Infestations

R1's earliest documented MPB activity within records reviewed occurred in the late 1800s on the Blackfeet and Coeur d'Alene National Forests (Evenden 1944, p. 1-2). The Beaverhead, Blackfeet, Coeur d'Alene, Flathead, Helena, Jefferson, Lolo, and Kootenai National Forests, as well as Glacier National Park, each experienced two separate infestation periods from 1909-1945 (Figures 3a and 3b). These included limited outbreaks that occurred from 1909-1917, during which the majority of pest activity was considered complete by 1913. This was followed by increasing MPB activity starting in 1917 that evolved to severe and widespread outbreak conditions in the 1920s and 1930s in National Forests throughout R1 (Evenden 1931; Evenden 1934; Evenden 1936-1943; Evenden 1944; Evenden 1946).

During the winter of 1932-1933, there was a severe cold event that was reported to reduce MPB populations within the Beaverhead National Forest and Yellowstone National Park. This event caused extensive overwintering larval mortality within lodgepole pine (Evenden 1934, p. 7; Furniss & Renkin 2003, p. 205). Evenden noted the substantial decline in the 1933 annual report:

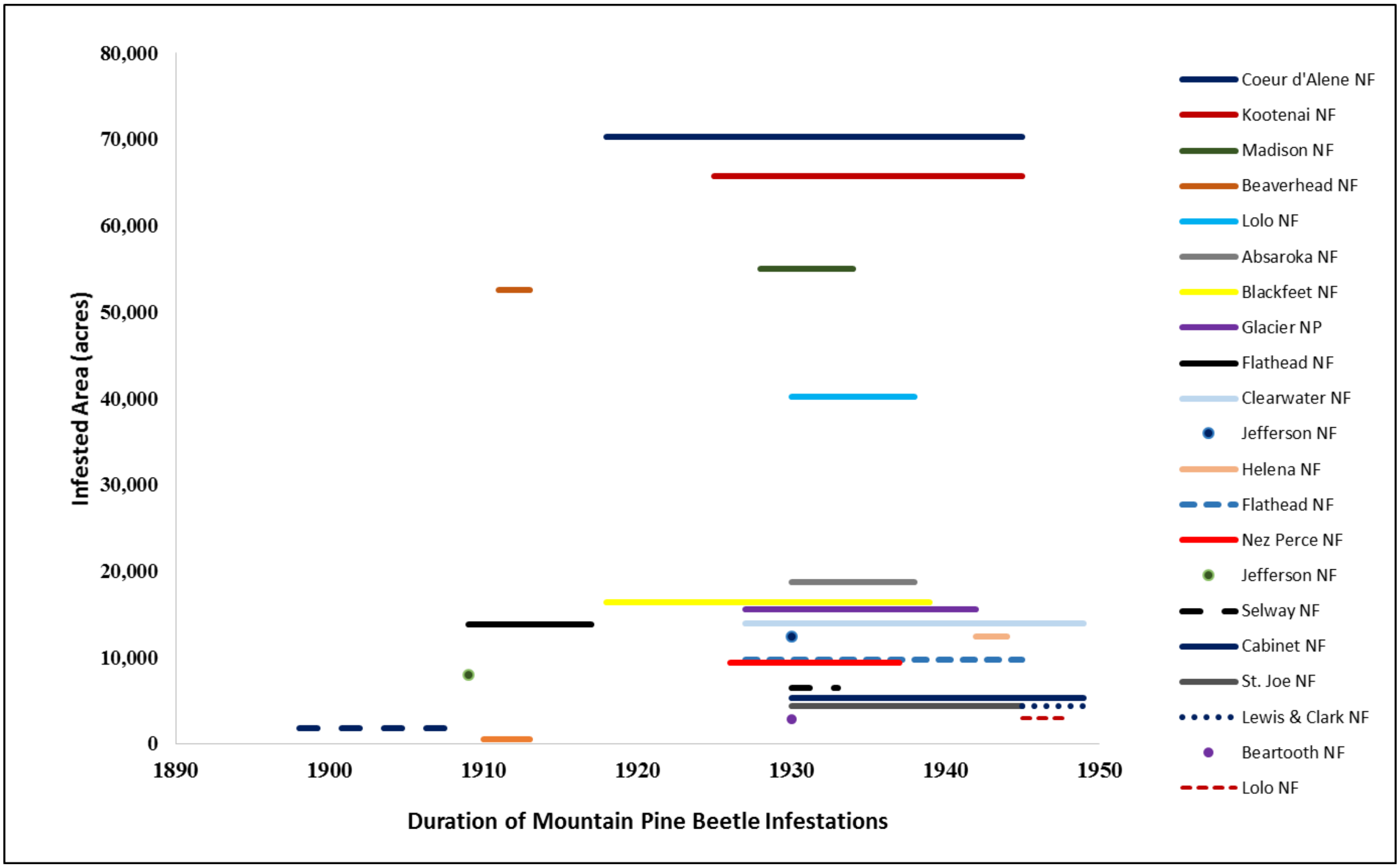
> *"A very outstanding reduction of 95%, or a drop from 17,500,000 infested trees in 1932 to 869,000 in 1933, occurred in the Beaverhead infestation during the past season. Though there are several factors which may have contributed toward this condition, it is believed that the extremely low temperatures of the past winter are primarily responsible"*
> (Evenden 1934, p. 7).

Populations amplified and recovered in areas with abundant hosts in 1934; however, broods were again subject to intense winter weather that year. Substantial declines in attacks were reported during the 1935 and 1936 seasons (Evenden & Gibson 1940, p. 273).

By the late 1940s, MPB had depleted available host trees to an extent that populations crashed and the majority of the outbreak was considered to have run its course across R1. After 1945, limited infestations were documented, but reports were scarce (Evenden 1946; Evenden 1948).

Figure 3a. Duration and spatial extent of mountain pine beetle infestations in Administrative Units with infestations mapped across < 100,000 acres

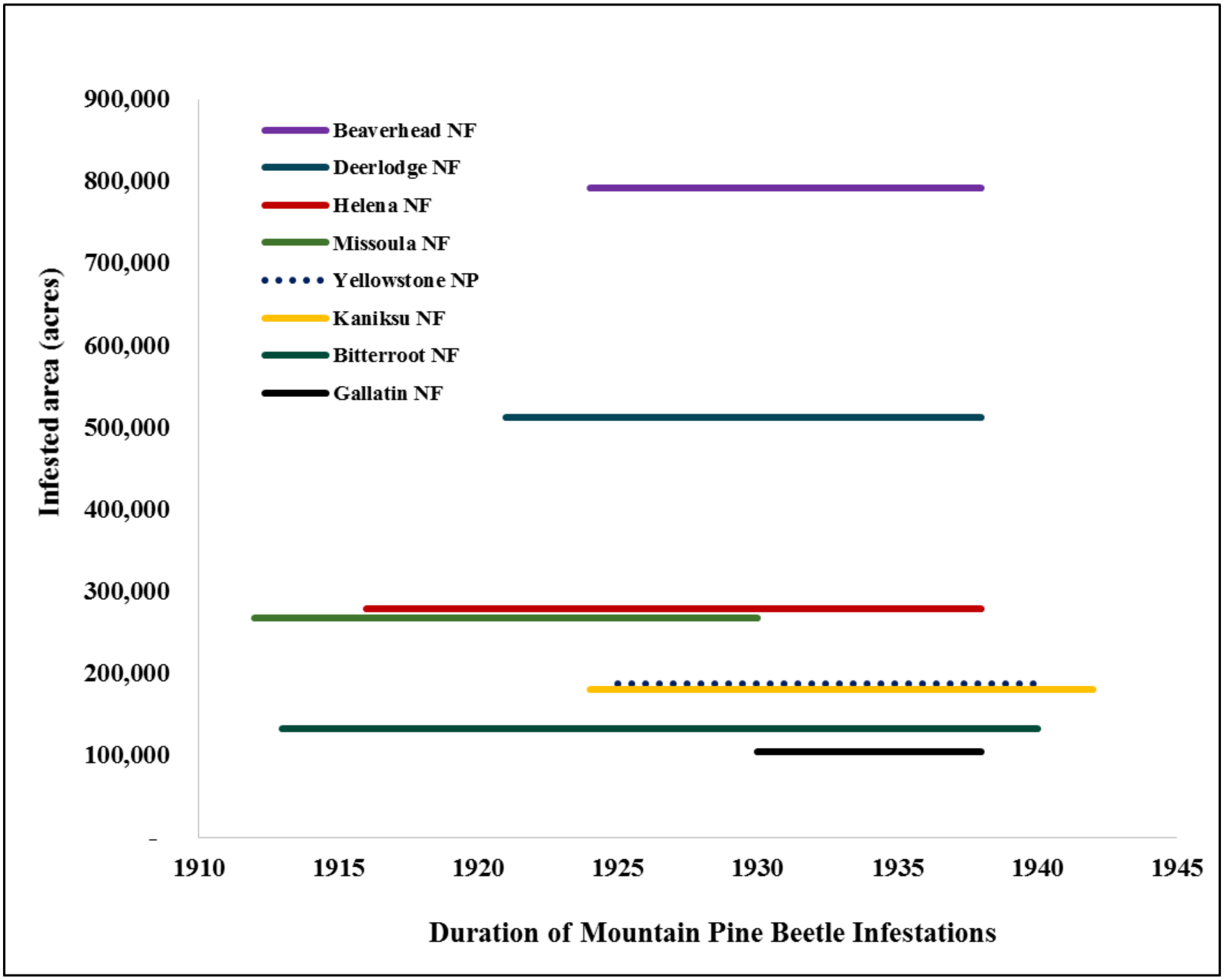
Note: MPB activity from 1946-1950 included only declining, scattered activity in limited locations



Entomologists chronicled the spread of MPB in areas of R1 as new locations were infested. In 1919, surveyors documented expansion southward from Seeley Lake to Lincoln, followed by further southern movement in lodgepole pine along both the east and west sides of the Continental Divide in 1921 (Evenden 1944, p. 8). An area of infestation located in the Blackfoot River watershed spread to the south on the west side of the Continental Divide, with new groups of dead lodgepole reported in 1923 (Evenden 1924, p. 10-11).

As the outbreak continued, managers hoped the Continental Divide would provide protection against MPB spread into the Big Hole Basin from heavily infested forests in East Fork of the Bitterroot River. During the 1924 survey season, however, entomologists felt that tree species and topography aided dispersal since both lodgepole and whitebark pine inhabited the low-lying portion located along the adjacent western edge of the Pintler Unit of the Beaverhead National Forest. This nearly unbroken zone of susceptible host continued to the southwest to the West Side Unit, providing a migration corridor from the Bitterroot National Forest to the Beaverhead National Forest (Gibson 1930, p .3; Evenden & Gibson 1940, p. 271).

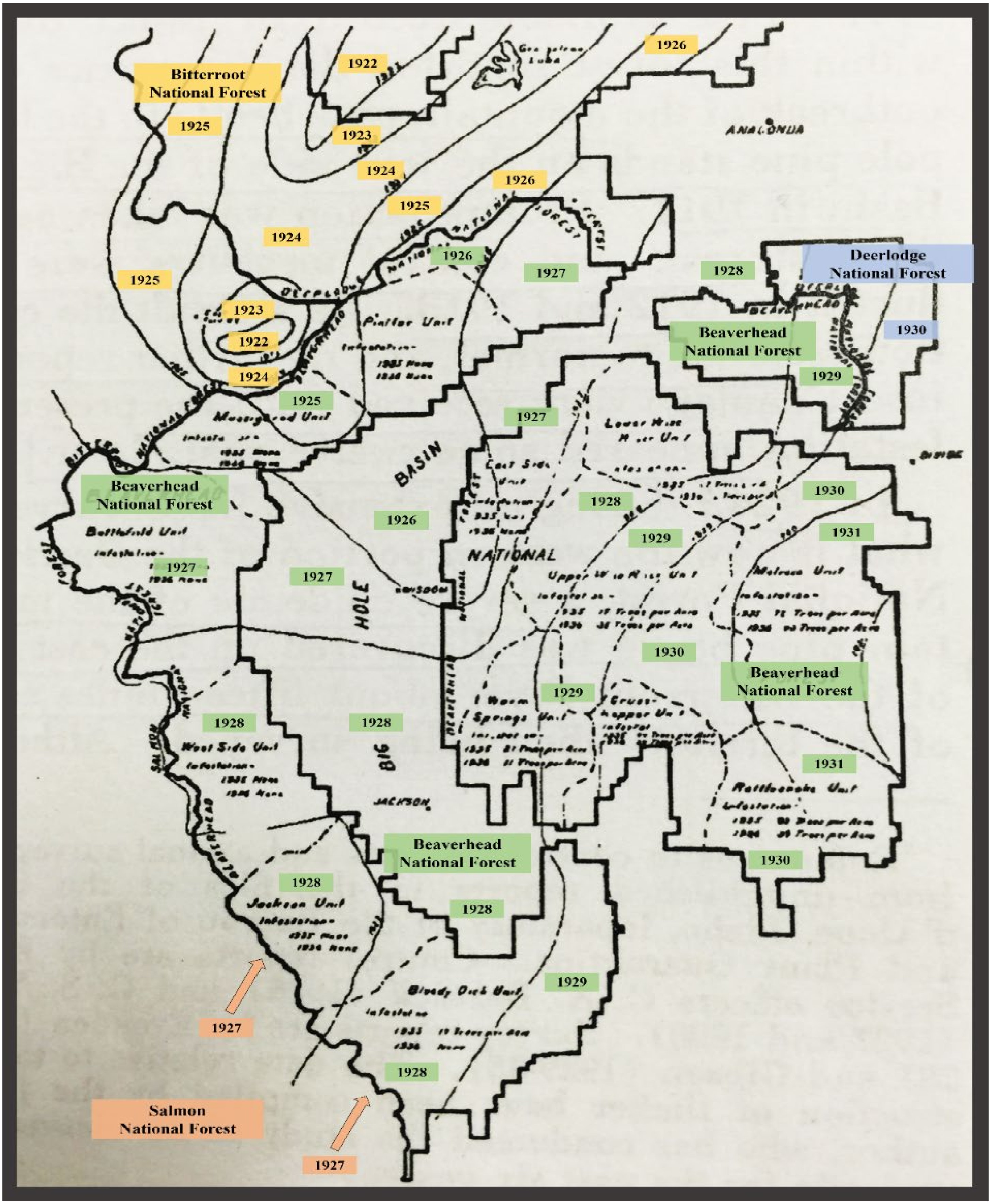
Figure 3b. Duration and spatial extent of mountain pine beetle infestations in Administrative Units with infestations mapped across > 100,000 acres



Subsequently, MPB colonized west side of the Big Hole Basin in 1925 then spread south and east (Figure 4). Entomologists reported MPB crossed the treeless area of the Basin, reached the east side in 1926, then colonized virtually all locations with susceptible host throughout the area. Severe infestation on the Salmon National Forest in Idaho was also thought to provide a continuous source of beetle activity to the Beaverhead National Forest during the mid-twenties to mid-thirties (Evenden & Gibson 1940, p. 272; Evenden 1944, p. 11).

Overall, the spatial expansion of the historic MPB outbreak event occurred primarily through short-range dispersals with beetles attacking adjacent, susceptible host trees. Long range dispersals likely occurred to a lesser extent and were thought to be responsible for new infestations distant from known activity clusters (Evenden 1944, p. 15). Extensive mortality centers manifested quickly and were reported to have a typical duration of 6-7 years within areas severely impacted:

Figure 4. Map of MPB progression through the Big Hole Basin, Beaverhead NF, from 1922-1931
Source: Evenden & Gibson 1940, Journal of Forestry, Figure 1, p. 272


Bitterroot National Forest
Deerlodge National Forest
Beaverhead National Forest
Salmon National Forest
ANACONDA
DIVIDE
BIG HOLE BASIN
WISDOM
JACKSON
Pintler Unit
Mussigbrod Unit
Battlefield Unit
West Side Unit
Jackson Unit
Bloody Dick Unit
Lower Wise River Unit
East Side Unit
Upper Wise River Unit
Warm Springs Unit
Grasshopper Unit
Melrose Unit
Rattlesnake Unit
1922
1923
1924
1925
1926
1927
1928
1929
1930
1931

> *"Events as recorded in this story leave no doubt as to the spread of the heavy centers or blocks of infestation. The development and progression of such centers was observed year after year in the Bitterroot and Beaverhead National Forests, and in the spread of the infestation across the national forests of Idaho. In such instances, a few scattered red tops are seen in an area of an otherwise unbroken canopy of green trees; the next year there are a few small spots of dead trees with more scattered red tops between; then larger groups, and in four or five years the entire area is red with the discolored foliage of dead trees"* (Evenden 1944, p.16).

II. Historic Management of Mountain Pine Beetle Infestations

Early forest managers, tasked with protection of the vast western timber supply, considered MPB infestations destructive to the Nation's timber supply. Extensive direct control efforts were implemented to suppress MPB populations and protect pine forests. These efforts were often successful with infestations that were small and occurred at a localized scale but were often ineffective at protecting residual vegetation in treated areas when outbreaks were severe and widespread. Management focused on treatments at early outbreak stages and, where ineffective, were ceased due to high costs and questionable efficacy (Kelley 1931, p. 2-3; Evenden 1931, p. 14).

Picture 1.
Evan Kelley,
Northern Region
Regional Forester
1929-1944
Source: USFS R1
Regional Office

Surveys were conducted to determine where MPB infestations were building in areas that threatened high-value forest resources and control measures took place for economic, aesthetic, and managerial reasons. Specifically, resource managers implemented costly treatments to protect stumpage value in areas designated for future timber harvests, preserve areas of priceless beauty; and to decrease fuel loading and fire dangers associated with high mortality rates caused by MPB infestations (Craighead 1929, p. 1,4). Additionally, severe MPB disturbance was associated with decline of valued early-seral, pine species and increase in late-seral species (including true firs) that were less desired in timber production areas. In 1929, the Chief Entomologist of the Bureau of Entomology and Plant Quarantine unit stated:

> *"In the white pine and lodgepole types of the northern Rockies bark beetles so affect the proportion of species in these stands as to convert the resulting forest into one of entirely different composition, often of inferior species, necessitating an entire reorganization of management plans"* (Craighead 1929, p. 4).

In May 1931, Regional Forester Evan Kelley (Picture 1) directed all Forest Supervisors in R1 to implement widespread management activities to reduce MPB impacts. As funding levels were insufficient to treat all infestations occurring at that time, policy prioritized management activities to detect and treat MPB infestations where there was 1) positive growth in year-over-year tree mortality rates; 2) developments of large clumps of infested trees; and 3) robust MPB brood development and survivorship was found during population surveys. Regional Forester Kelley highlighted the importance of survey work to ensure immediate detection of MPB outbreaks and held each forest accountable to document survey findings to ensure limited funding was efficiently allocated for infestation control work (Kelley 1931, p. 1-4).

Direct Control: Administration

Historic forest entomological management was administered by the U.S. Department of Agriculture, Bureau of Entomology and Plant Quarantine which originated in 1863 as the Division of Entomology. Subsequently, this organization reclassified as the Bureau of Entomology in 1904 then combined to form the Bureau of Entomology and Plant Quarentine in 1934 (Henneberry 2008, p. 14-15, 20). Under both former and latter Bureaus (referred to holistically as BOEPQ in remainder of this report), the Division of Forest Insect Investigations was responsible for oversight and execution of widespread MPB control attempts that occurred throughout R1 during the early 20th century outbreak events (Picture 2). In 1942, the Agricultural Research Administration was tasked with reorganizing government research bureaus, including the Bureau of Entomology and Plant Quarantine's Division of Forest Insect Investigations, and responsibilities were eventually divided between U.S. Forest Service branches of Research and State and Private Forestry (Henneberry 2008, p. 22).

> *"The responsibility for the investigations of insects affecting forests or, in other words, the biological facts on which control rests has been invested by law in the Bureau of Entomology"*
> (Craighead 1929, p. 5).

The BOEPQ coordinated control activities across various resource management agencies and private land owners. In 1920, the Secretary of Agriculture issued a memorandum identifying Bureau responsibilities to conduct MPB infestation surveys, advise resource managers on control techniques and necessity, and provide direct field supervision where needed. The magnitude of infestations catalyzed cooperation as federal agencies and private landowners assisted Bureau crews with field work, funding for labor costs, and treatment implementation (Craighead 1929, p. 5).

As the epidemic progressed, agencies, governments, and private landowners coordinated their efforts to research, test, and implement effective treatment strategies. Detailed forms to track expenses from equipment, transportation, camp requirements, and labor in a consistent manner were developed to compare cost-effectiveness and efficacy of divergent control techniques utilized (Evenden 1931d, p. 1-2).

The BOEPQ faced many logistic difficulties in implementing a widespread direct control program across R1. Issues with R1's long-lasting winters, inclement spring weather, and short opportunity windows for direct control treatments prior to MPB emergence from infested trees often left crews with only 30-40 days to perform control work. BOEPQ deployed various-sized crews based on outbreak extent and number of infested trees prescribed for treatment. Camp locations were contingent on accessibility, fuel availability, and water resources. Fewer camps of substantial size (potentially containing 100s of personnel) were found to be more economical than numerous, smaller camps, as the fixed operational costs for transportation, cooks, and equipment were decreased. Camps were centralized between known infestation epicenters and where outbreaks were spreading (Evenden 1931d, p. 2-3).

Picture 2. Forest Insect Investigation western staff meeting in Pingree Park, Colorado, 1937. Back row from left: G.R. Hopping; unknown; F.P. Keen; J.M. Miller; and N.D. Wygant. Front Row: F.C. Craighead, Chief, Washington, D.C.; D. De Leon; J.A. Beal; C.L. Massey; J.C. Evenden; unknown; and W. Howe. (Furniss 2007, RMRS-GTR-195, Figure 8, p. 7).

Direct Control: Survey Techniques

Project supervisors were responsible for operations that included camp organization, supply procurement, infestation surveys, treatment technique decision, crew deployments, and post-treatment surveys. Of these various facets, having well-trained spotting crews was critical. Treatment measures were most productive when spotting surveys were completed prior to deploying control crews. Officials recommended having spotting crews start seven to ten days ahead of modest-sized control crews. Additional members could then be assigned to control various control crews as they directly followed the spotting crew's. Efficient coordination was essential due to short implementation windows (Evenden 1926, p. 3-4).

Locating all infested trees was essential for successful control treatments as residual infested trees had potential for re-infestation (Evenden 1930a, p. 1&5). Protocols evolved to collect infestation data from smaller representative surveys that covered substantial areas of potential infestation. A series of one-chain-wide 'strips' were sampled along each cardinal compass direction. Strips started from a random point and run for a set length then an additional offset strip was surveyed back to the initiation area with reverse bearings. Sample strips followed a cardinal compass bearing to reduce potential for surveyor's getting lost. Total numbers of infested trees and area surveyed were used to determine need for direct control implementation (Evenden 1931c, p. 1-4).

Vast or pure lodgepole or western white pine stands protocols included breaking large areas into grids and often completing strip surveys. Lodgepole pine surveys required a five-man crew while a three-man crew was ideal to survey western white pine stands (Evenden 1929, p. 11; Evenden 1930a, p. 2). Surveyors also estimated and mapped fading foliage with a 'topographic methodology' then dispatched control crews to identified locations. This method was beneficial in open terrain and allowed one or two spotters to productively canvas expansive areas (Evenden 1929, p. 13-14; Evenden 1930a, p. 6).

Direct Control: Treatment Methods

Direct control treatments varied by species and preferred methods progressed through the outbreak period. See Appendix A for a series of photographs that documented the progression of typical direct control efforts in 1927 from an example area in the Big Hole Basin of the Beaverhead National Forest.

Treatment of infested lodgepole pines incorporated three control techniques which often were combined to ensure MPB brood mortality. These practices were 1) burning infested-tree log decks; 2) burning of standing trees; and/or 3) bark removal with various peeling methods. The burning methods often used the piling and burning of brush and application of fuel oil. Control crews treated infested trees as soon as areas were accessible and infested trees were located. Fire was used as a sanitation tool typically until July 1st when ambient weather conditions increased wildfire risk. After this date, peeling was the primary method of killing MPB brood (Evenden 1926, p. 17, 19, 42; Evenden 1931d, p. 5).

The decking and burning method required a seven-man crew that included a foreman, two sawyers, a swamper, a skidder and horse, and two men responsible for burning. Sawyers felled, limbed, and cut trees into twelve to sixteen-foot sections through the length of the infested bole. Protocol was to remove all portions of a bole until inner-bark infestations and blue-stain fungi were absent. Stump-height was capped at six inches so that peeling was not required. To burn log decks, swampers piled brush and a skidder with a horse and chain oriented and stacked infested-tree piles that were at least three logs high to guarantee a suitable airflow for the fire. Trenches were dug six feet from the log decks before lighting to prevent fire spread. During dry weather, crews lit the decks after 1900 hours and allowed them to burn through the night. Decking and burning was considered more cost-effective than peeling methods and was favored where topography allowed for decking logs (Evenden 1926, p. 17-19).

The burning-standing method of control occurred where topography or other factors precluded the infested deck burning. This method required a crew of four to five men and consisted of a foreman, a packer with a horse, and two or three burners. With foreman supervision, the packer dispersed drums of fuel oil to strategic locations. Working in pairs, the burners applied oil to infested trees with tanks seventy-five percent full, pumped to approximately twenty pounds of pressure, and outfitted with up to nine-foot long brass extenders. All sides of an infested tree was saturated up to 30-feet in height. Once lit, burners sprayed fuel to the base of an infested tree to promote excessive heat. As the blaze hit the top of the oil-soaked section of the trunk, burners would spray additional oil with the extender which allowed flames to burn substantially higher. This was highly beneficial as MPB infestations ranged up to 60-feet in height within infested lodgepole pines (Evenden 1931d, pg.13-16; Evenden 1932, p. 2-3).

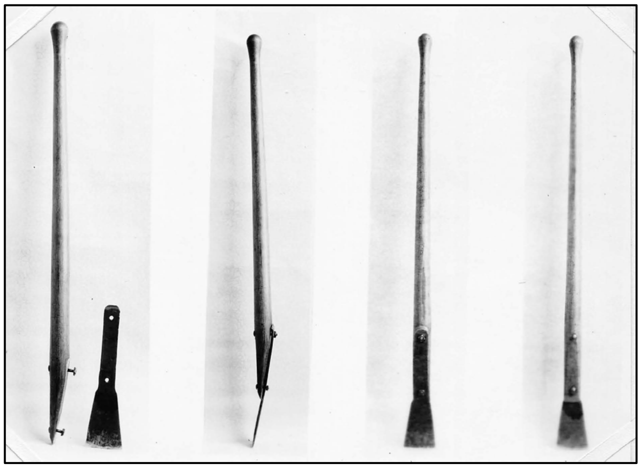
The standing-burning method was economical but had several downsides. The corrosive nature of the fuel oil required burners to wear protective clothing as direct skin contact would cause blistering. Additionally, substantial fuel oil was needed to ensure burning temperatures got high enough to kill MPB brood. Tall trees that had high infestations required special treatments that required slash to be heaped to high levels and angling numerous pole-sized trees against the base an infested tree. Some infested trees had brood up to five to six-inch top and were to tall even for the modified standing-burning methods. If the height of the infestation could not be absolutely inferred, felling and burning occurred instead. Finally, the burning-standing method was not effective or advisable during wind events or when stems were covered by rain or snow (Evenden 1931d, p. 13-16, 20; Evenden 1932, p. 2).

Picture 3. Crew peeling MPB-infested western white pine (Rust 1930, p. 36).

Methods to peel infested lodgepole pines were more labor-intensive and costly relative to the burning techniques. Peeling treatments were executed by seven or eight men. Two fallers were responsible for felling, bucking, limbing, and identifying the length of infestation where peeling was needed. The remaining crew members peeled infested-tree inner-bark layers. A modified technique of peeling standing-infested trees occurred on occasion. Peeling the standing-infested trees was sometimes considered less costly as it saved labor efforts to fell and buck boles; however, efficacy was questioned as peelers were limited to lower-bole areas and infestations higher than arm's reach were not treated (Evenden 1926, p. 19-20).

Felling and peeling was the technique typically used to treat infested western white pines that were typically larger in diameter relative to lodgepole pines (Picture 3). Infestations in this host were typically single trees rather than groups and supervisors found that a three-man crew was ideal to transport peeling tools and implement treatments. Crews recorded MPB infestations extending to six-inch tops in some western white pines while other infestations were limited to lower-bole areas. Sawyers were guided to fall trees in an orientation that promoted subsequent rolling so inner-bark peeling could treat the entire bole circumference (Evenden 1929, p. 17-18).

A variety of tools were used to implement bark peeling treatments. In 1926, Ed Henrich, a lumberman supervising the Pete Creek Insect Control Project on the Kootenai National Forest, created a peeling spud capable of removing thick, sloughing bark as well as tight, thinner bark of tree tops (Picture 4). With a hickory handle and plowshare steel, the spud could continue peeling through fine limbs and knots. This tool, named Henrich's Peeling Spud, became widely used and the daily treatment rates by thirty to thirty-five percent (Evenden 1927a, p. 1-2).

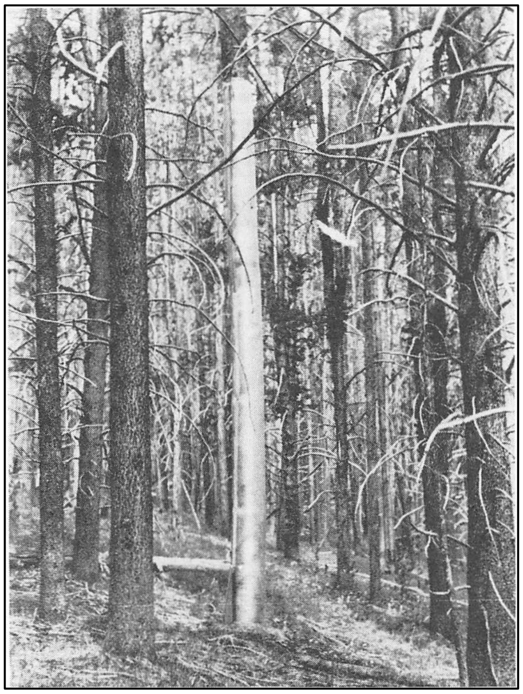


Picture 4. Henrich's Peeling Spud (Evenden 1927a, p. 3)

Experimental Direct Control Research

Early entomologists experimented with several strategies to kill MPB brood. These included developing novel pesticide/carrier combinations such as stove oils combined with orthodichlorobenzene and naphthalene (Gibson 1939, p. 1-2). Sprays and dusts consisting of chemicals such as pyridine, orthene, zinc-meta-arsenate, sodium fluosilicate, and paradichlorobenzene were also tested (Gibson 1933, p. 1-6). Additionally, physical impediments, including screens and cement, were also tested to prevent MPB-attack (Picture 5; Evenden 1934, p. 16).

Systemic insecticides were experimented with to kill MPB brood in western white pines. Trees were injected with copper sulphate, zinc chloride, ammonium fluoride, and sodium thiocyanate pesticides. Injection methods included

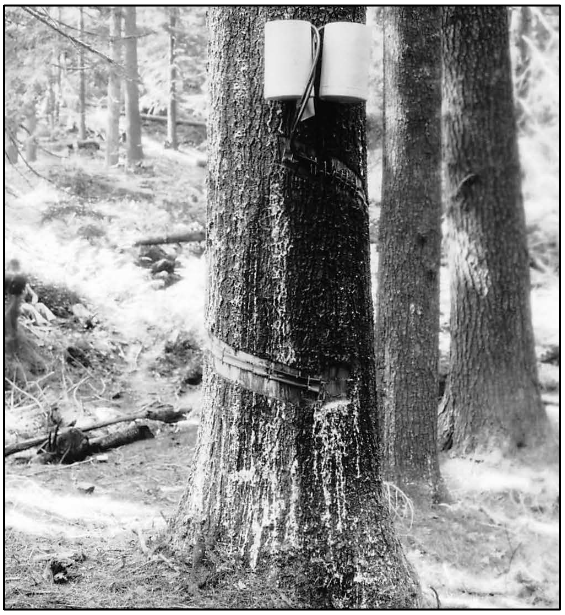


Picture 5. Lodgepole pine with screen barrier around bole to prevent MPB attacks (Evenden, Bedard, and Struble 1943, p. 24).

rubber-banding infested trees or collaring them with rubber, paper, or tin. Both approaches were accomplished with a 'saw-kerf' which was a cut the width of the saw that encircled a tree's bole.

A thin strip of bark was removed under the 'saw kerf' to ensure a good fit. Rubber bands and collars were stapled or nailed in place to inject chemical solutions into the cambium of the treatment tree. Copper tubing was inserted into holes drilled into the 'saw kerf' then attached to gallon-size cartons filled pesticides (Picture 6; Bedard 1936, p. 4-8).

Early systemic attempts at MPB control only had limited success. Most tests were considered either inconclusive or failures. Some methods proved too costly and those with partial success were only demonstrated useful for small recreation areas (Gibson 1936a, p. 5-6). Even so, managers recommended further tests over larger areas to assess the potential for effective MPB control (Evenden 1934, p. 16; Bedard 1937, p. 9).



Picture 6. Rubber-band method of injecting poison into MPB-infested western white pine (Bedard 1936, p. 8).

Strategies to promote MPB natural enemy populations were incorporated as direct control strategies evolved. Control efforts transitioned from removal of all identified infested trees to preserving standing 'parasite trees' to reduce MPB populations that were missed as "100% eradication [was] an economic impossibility" (Picture 7; Bedard 1933, p. 1,6). In 1933, treatments on the Coeur d'Alene National Forest left western white pine trees that housed natural enemies such as parasitic wasps (including *Coeloides dendroctoni*) and trees where other predators were identified (Bedard 1933, p. 6; Evenden 1934, pg.15).

Picture 7. *Coeloides dendroctoni* cocoons in MPB larval galleries of "parasite trees" (Bedard 1933, p. 11).

Direct Control: Efficacy and Cost

MPB direct control operations were often effective in locations where infestations were at early stage or spatially limited. Conversely, where infestations were spatially widespread, costly treatment efforts often failed to prevent subsequent mortality within treated areas and adjacent, susceptible pine forests. These efficacy findings and costs are summarized for site-specific control projects in detail so they can inform modern management discussions.

From 1909-1913, control efforts were considered successful after surveys indicated reduced MPB activity the year post-treatment in lodgepole pine near the southern shore of Swan Lake on the Flathead National Forest, western white pine stands in the

McDonald-Mineral Creek basin of Glacier National Park, and lodgepole pine on the northwest side of the Big Hole Basin of the Beaverhead National Forest (Evenden 1931; Evenden 1944).

During the major outbreak period from 1917-1942, some smaller treatment efforts were considered successful as MPB activity was reduced the year following treatment. These areas included treatments of lodgepole pine in Hunter's Gulch on the Helena National Forest in 1923, western white pine blow-down near the Musselshell Ranger Station on the Clearwater National Forest in 1931, and in western white pine throughout the Smith Creek drainage on the Kaniksu National Forest in 1937 (Evenden 1923; Evenden 1931; Terrell & Evenden 1938c). While these areas were considered short-term successes, they often did not prevent long-term MPB activity as populations increased once treatments were stopped.

Managers spent the most funding on control efforts to treat infested lodgepole pine stands from 1917-1942. Many of these stands had no benefit from treatments as MPB outbreaks continued to spread and cause severe mortality post-treatment. Finding increased infestations post-treatment was common after many control projects (Evenden & Gibson 1940, p. 273; Evenden 1944, p. 9). In some locations, losses occurred quicker than it was feasible to conduct survey, plan control effort logistics, and deploy direct control treatment crews. In these instances, control was not recommended, as Evenden (1928a) indicated for the Missoula National Forest MPB:

> *"The thoughts of control seem nearly as prohibitive for this region as for the Bitterroot or Beaverhead…would be not only a very uneconomical operation, but one which would be entomologically unsound"*
> (Evenden 1928a, p. 3).

Managers repeatedly tried to strategically deploy direct control crews to prevent large MPB outbreaks from spreading with 'barrier zones' or 'defense lines' where they hoped beetles would not cross. These either failed or were abandoned after planning stages after MPB populations were found within areas beyond the 'barrier zones' (Evenden 1944, p. 9).

Overall, control efforts in lodgepole pine forests during severe and widespread MPB outbreaks was ineffective and its natural constraints such as host depletion, weather, or larval predation to interrupt these large-scale disturbance events (Evenden 1923, p. 3; Gibson 1935, p. 12; Evenden & Gibson 1940, p. 273).

In western white pine forests, in which pines are spatially isolated relative to lodgepole pine forests that often have large tracks of contiguous, even-aged host, direct control was considered largely successful from 1917-1942. Managers from Coeur d'Alene and Kootenai National Forests reported that control decreased volume loss and reduced infestation severity in western white pine forests. They noted that once MPB infestations were reduced sufficiently, populations did not increase after direct control treatments ceased (Evenden 1934, p. 5).

These treatments in western white pine forests required a substantial amount of funding to implement and managers questioned where the optimal control point was to balance treating a sufficient percentage of infested trees to reduce impacts versus total expense. As an example of cost, for the Coeur d'Alene 1930 Bark Beetle Control Project over $140,000 was spent to treat 23,000 infested western white pines. According to the U.S. Bureau of Labor Statistics, that is equivalent to a 2018 inflation-adjusted value of just over 2 million dollars (Bureau of Labor Statistics). In the following decade an additional $200,000, or inflation-adjusted $3.7 million, was spent to control "hot-spots" of infestation for this control project (Evenden 1940, p. 6).

The Agricultural Research Administration's Forest Insect Laboratory in Coeur d'Alene, Idaho reported from 1910-1945 the Department of Agriculture spent $750,000, inflation-adjusted of $10.9 million, on bark beetle direct control efforts that primarily targeted MPBs throughout R1 (Picture 8; Evenden 1945, p. 13). Additionally, thousands of dollars were spent by the National Park Service, Bureau of Indian Affairs, and private land owners (Craighead 1929, p. 15). Public officials regarded this funding to be reasonable relative to exorbitant losses in timber harvest values. Managers often cited inadequate funding as reasons for unsuccessful control operations (Evenden 1945, p. 13).

Picture 8. Forest Insect Laboratory Coeur d'Alene, Idaho (Evenden 1940a, p. 13)

Entomologists at the Bureau of Entomology and Plant Quarantine used these findings to promote a comprehensive, productive entomological program to curtail infestations in the Northern Region. They recommended:

> *"1. Additional research…provides a foundation upon which both artificial control and the preventative efforts of silvicultural management must stand;*
>
> *2. Adequate program of forest insect surveys…[so] control measures can be directed against insect outbreaks at a time when the greatest results will follow minimum expenditures of funds. Failure to recognize early stages of dangerous outbreaks permit them to develop to such proportions that control measures are no longer feasible and tremendous losses of timber can occur;*
>
> *3. Provisions for a proper institution of artificial control when and where needed"*
>
> (Evenden 1945, p. 13)

These suggestions helped derive 1) policy legislation that mandated cooperation between federal and local governments, management agencies, and private ownerships; 2) a comprehensive forest pest monitoring program to detect infestations with aerial surveys; and 3) further research into silviculture-based indirect control activities (e.g. stand-level thinning) to reduce conditions susceptible to bark beetle colonization and prevent bark beetle outbreaks (Salman & Bongberg 1942; Hall & Davies 1968).

Forest Pest Legislation Following Severe Bark Beetle Outbreaks in Western U.S.

The MPB outbreaks across R1, as well as throughout other western U.S. forests (Miller 1944; Miller and Keen 1960), resulted in swift legislative action passed by the 80th U.S. Congress to protect forest resources from insects and disease. The Forest Pest Control Act was signed into law on June 25, 1947 (Division of Forest Insect Investigations Staff [DFIIS] 1951, p. 1,14). The intent of this act was to provide for insect control activities across state, private, and federal jurisdictions:

> *"In order to protect and preserve forest resources of the United States from the ravages of bark beetles, defoliators, blights, wilts, and other destructive*

> *forest insect pests and diseases, and thereby enhance the growth and maintenance of forests, promote the stability of forest-using industries and employment associated therewith, aid in fire control by reducing the menace created by dying and dead trees injured or killed by insects or disease, conserve forest cover on watersheds, and protect recreational and other values of forests, it shall be the policy of the Government of the United States independently and through cooperation with the Governments of States, Territories, and possessions, and private timber owners to prevent, retard, control, suppress, or eradicate incipient, potential, or emergency outbreaks of destructive insects and diseases on, or threatening, all forest lands irrespective of ownership"* (DFIIS 1951, p. 13).

Section 5 of the Forest Pest Control Act defined what appropriated funds were to be used for:

> *"There are hereby authorized to be appropriated for the purposes of this Act such sums as the Congress may from time to time determine to be necessary. Any sums so appropriated shall be available for necessary expenses, including the employment of persons and means in the District of Columbia and elsewhere, printing and binding, and the purchase, maintenance, operation, and exchange of passenger-carrying vehicles… Materials and equipment necessary to control, suppress, or eradicate infestations of forest insects or tree diseases may be procured…under such procedures as may be prescribed by the Secretary of Agriculture, when deemed necessary in the public interest"* (DFIIS 1951, p. 14).

Legislators appropriated funds for direct control surveys and implementation in March 1948 when $978,000 (inflation-adjusted $10.2 million in 2018 valuation) was authorized to be used through June 30, 1949 (previous end of Fiscal Year). Subsequently, an additional $750,000 (inflation-adjusted $7.9 million) was appropriated on September 30th, 1949 and soon after $250,000 (inflation-adjusted $2.6 million) was authorized for 'emergency outbreak funding'. In total, $1 million (inflation-adjusted $10.5 million) was appropriated combat forest insect pests in the late-1940s (Statutes-at-large/ 80th-congress/session 2 ; statutes-at-large/80th-congress/session-2).

Forest entomologists applauded these laws and funding which led to substantial inter-agency coordination:

> *"The activation of this law has become a forward step in programs of forest protection, and each year will be a more important factor in forest planning"* (Evenden 1950, p. 1).

Eventually, the Bureau of Entomology, Division of Forest Insects was reassigned to the Forest Service, Forest Insect Research Division, Coeur d'Alene, ID in 1953 (Henneberry 2008, p. 24). In 1961, this program was transferred to Forest Service Regional Office in Missoula, MT under the administration of State and Private Forestry (U.S.F.S. Staff 1961, p. 1). Since that time, the program has undergone various name changes with 'management' or 'control' in the title. In 2000, the program was designated Forest Health Protection. Current mission objectives are to implement an integrated forest pest management program, of which direct control is a small part, to specifically:

> *"facilitate stewardship, protection, and management of forested ecosystems by promoting forest health to federal, state, and private resource partners…To help people understand the effects various agents have on*

> *their forests, the alternatives they have to influence those effects, and ways that treatments can be integrated to meet multiple objectives"* (forest-grassland health).

III. Forest-Level Summaries of Mountain Pine Beetle Impact and Management from 1909-1945

Forest Summaries

Following are forest-by-forest summaries that include the name, Forest/Park origination year, Forest unit inclusions and/or divisions with respective timeframes, MPB outbreak period, MPB total acreage of damage mapped/impacted, pine species affected, and management that occurred.

Figure 1 shows the Northern Region's historic 23 National Forest divisions and two National Parks. Administrative unit summaries are presented in alphabetical order based on geographic sections of R1: the northwest, central, and southeast sections.

The northwest section (Figure 6) units included the Blackfeet, Cabinet, Coeur d'Alene, Flathead, Kaniksu & Pend Oreille, Kootenai, Lewis and Clark, and St. Joe National Forests, along with Glacier National Park.

The central section (Figure 7) units consisted of the Lolo, Beaverhead, Bitterroot, Deer Lodge, Helena, Jefferson, Missoula, Clearwater, Nez Perce, and Selway National Forests.

The southeast section (Figure 8) included the Absaroka, Beartooth, Gallatin, and Madison National Forests, along with Yellowstone National Park.

Figure 6. MPB activity by tree species in Northwest section, Northern Region, 1909-1945

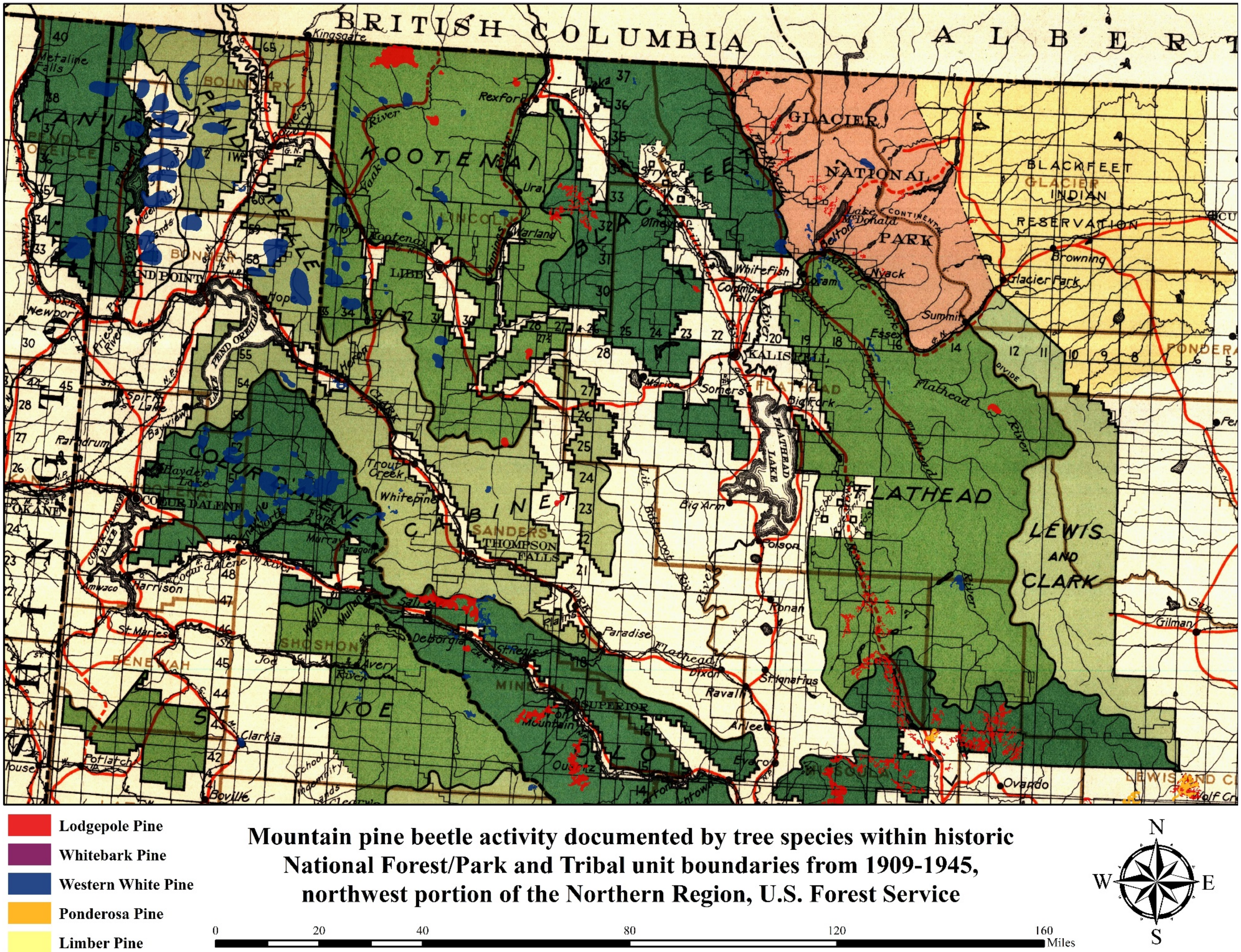
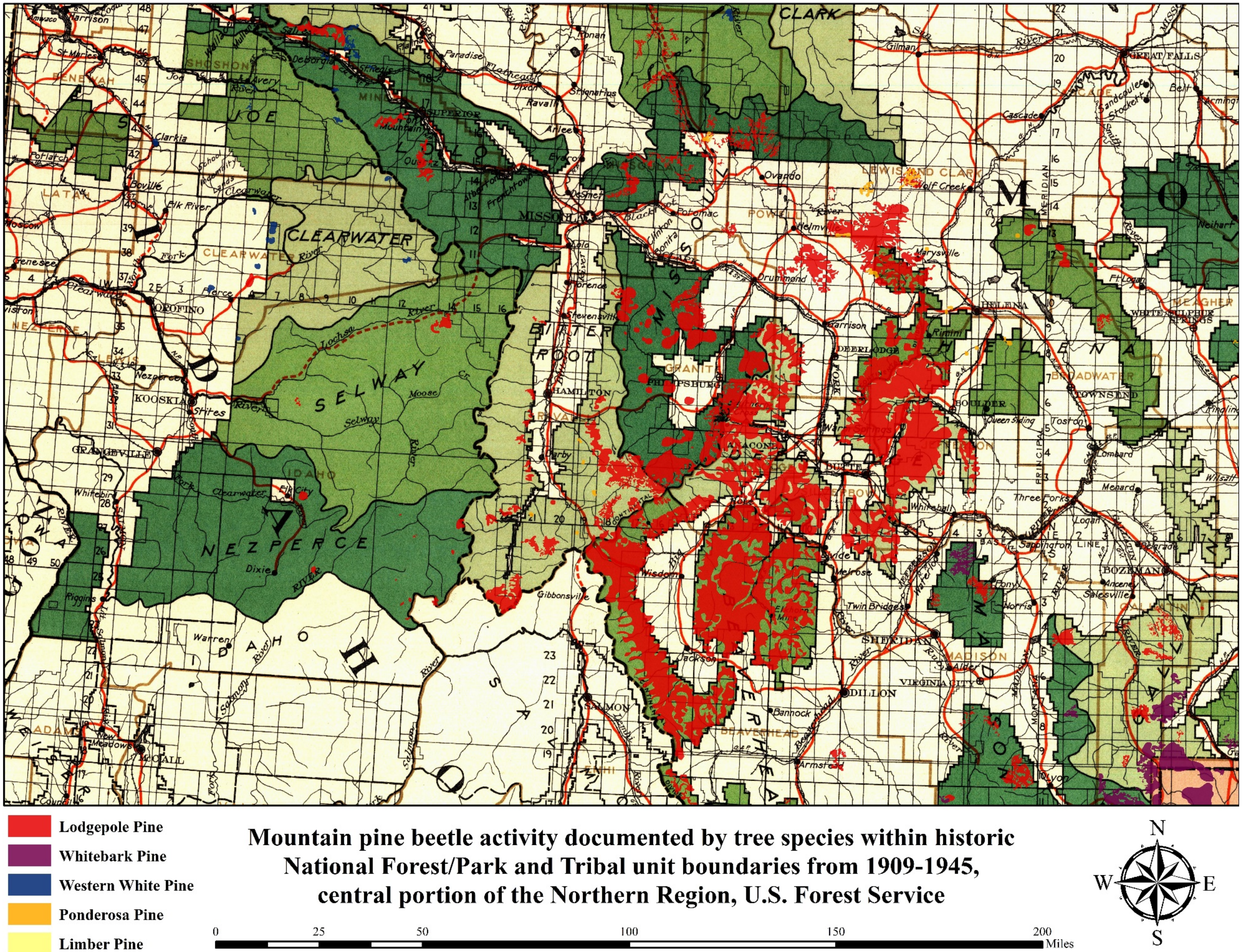
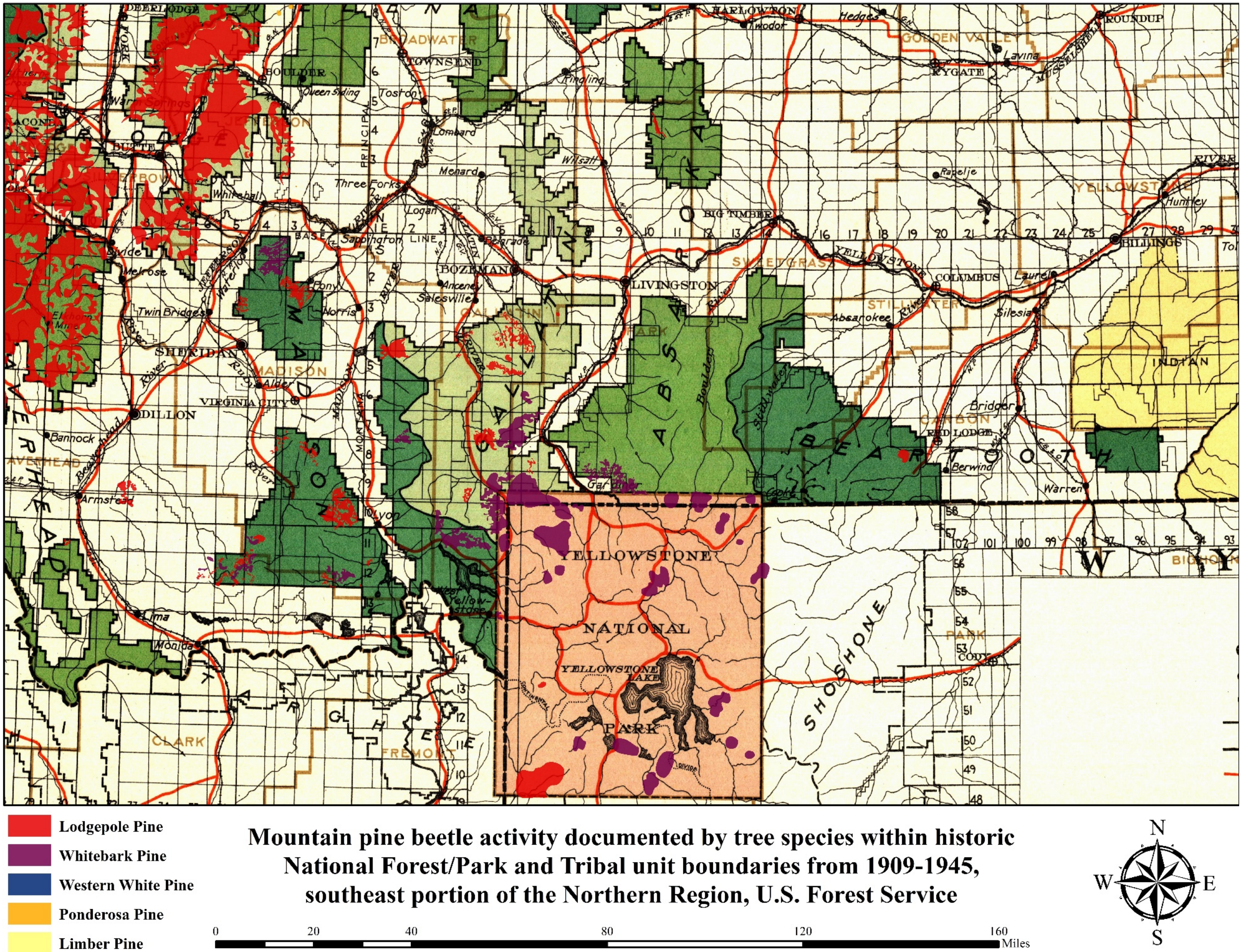

BRITISH COLUMBIA
ALBERTA
KANIKSU
PEND OREILLE
KOOTENAI
LINCOLN
BLACKFEET
GLACIER NATIONAL PARK
BLACKFEET GLACIER INDIAN RESERVATION
PEND OREILLE
COEUR D'ALENE
CABINET
SANDERS
FLATHEAD
LEWIS AND CLARK
ST JOE
SHOSHONE
BENEWAH
MINERAL
LOLO
Kalispell
Libby
Sandpoint
Whitefish
Browning
Superior
Thompson Falls
Flathead Lake
🟥 Lodgepole Pine
🟪 Whitebark Pine
🟦 Western White Pine
🟧 Ponderosa Pine
🟨 Limber Pine
Mountain pine beetle activity documented by tree species within historic National Forest/Park and Tribal unit boundaries from 1909-1945, northwest portion of the Northern Region, U.S. Forest Service
0
20
40
80
120
160
Miles
N
S
E
W

Figure 7. MPB activity by tree species in Central section, Northern Region, 1909-1945


🟥 Lodgepole Pine
🟪 Whitebark Pine
🟦 Western White Pine
🟧 Ponderosa Pine
🟨 Limber Pine
0
25
50
100
150
200
Miles
N
W
E
S
CLARK
GREAT FALLS
Gilman
Ronan
Paradise
Dixon
Ravalli
Arlee
Evaro
St. Ignatius
Superior
MISSOULA
Ovando
Wolf Creek
LEWIS AND CLARK
Helmville
Potomac
Marysville
Drummond
HELENA
Garrison
DEERLODGE
Rimini
Philipsburg
GRANITE
BOULDER
TOWNSEND
BROADWATER
Toston
Three Forks
Logan
BOZEMAN
Anceney
Salesville
GALLATIN
Belgrade
Menard
Lombard
Wilsall
Ringling
MEAGHER
WHITE SULPHUR SPRINGS
Ft. Logan
Neihart
Cascade
Belt
Stockett
Sandcoulee
CASCADE
Armington
BUTTE
ANACONDA
Whitehall
Divide
Wisdom
Melrose
Twin Bridges
SHERIDAN
Alder
VIRGINIA CITY
MADISON
DILLON
Bannock
Armstead
BEAVERHEAD
Jackson
Gibbonsville
SALMON
HAMILTON
Darby
Stevensville
Florence
Lolo
BITTER ROOT
SELWAY
Lochsa
Moose
NEZPERCE
Elk City
Dixie
Warren
CLEARWATER
OROFINO
KOOSKIA
Stites
GRANGEVILLE
Whitebird
Riggins
New Meadows
McCALL
Nezperce
Pierce
Elk River
Bovill
Moscow
Genesee
LATAH
Potlatch
Clarkia
ST. JOE
Avery
St. Maries
BENEWAH
SHOSHONE
Harrison
Wallace
Mullan
DeBorgia
St. Regis
MINERAL
LOLO
Alberton
Frenchtown
Quartz
Saltese
MISSOULA
POWELL
DEER LODGE
HELENA
PRINCIPAL MERIDIAN
BASE LINE
Sappington
Pony
Norris
Lyon
IDAHO
MONTANA

Mountain pine beetle activity documented by tree species within historic National Forest/Park and Tribal unit boundaries from 1909-1945, central portion of the Northern Region, U.S. Forest Service

Figure 8. MPB activity by tree species in Southeast section, Northern Region, 1909-1945


DEERLODGE
BOULDER
BROADWATER
TOWNSEND
HARLOWTON
Hedges
GOLDEN VALLEY
Lavina
RYGATE
ROUNDUP
Queen Siding
Toston
Ringling
Lombard
BUTTE
JEFFERSON
Warm Springs
Wilsall
Menard
Three Forks
Whitehall
Rapelje
YELLOWSTONE
Huntley
BIG TIMBER
Logan
Sappington
BASE LINE
Belgrade
BOZEMAN
LIVINGSTON
SWEETGRASS
COLUMBUS
Laurel
BILLINGS
Divide
Melrose
Pony
Anceney
Salesville
Norris
Twin Bridges
GALLATIN
STILLWATER
Absarokee
Silesia
SHERIDAN
MADISON
Alder
VIRGINIA CITY
INDIAN
DILLON
ABSAROKA
Bridger
CARBON
RED LODGE
Bannock
BEARTOOTH
Berwind
BEAVERHEAD
Gardiner
Cooke
Warren
Armstead
YELLOWSTONE NATIONAL PARK
YELLOWSTONE LAKE
SHOSHONE
PARK
CODY
West Yellowstone
Lima
Monida
TARGHEE
CLARK
FREMONT
BIGHORN
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20
40
80
120
160
Miles

🟥 Lodgepole Pine

🟪 Whitebark Pine

🟦 Western White Pine

🟧 Ponderosa Pine

🟨 Limber Pine

Mountain pine beetle activity documented by tree species within historic National Forest/Park and Tribal unit boundaries from 1909-1945, southeast portion of the Northern Region, U.S. Forest Service

National Forests and Parks in Northwestern Section of the Northern Region

Blackfeet National Forest

Outbreak Period: 1898-1909 & 1918-1939
Area Mapped: 18,166 acres
Species Impacted: lodgepole pine and western white pine

The Blackfeet National Forest was created in 1908 then divided among the Flathead and Kootenai National Forests in 1935. An early MPB infestation that occurred from 1898-1909 was recorded in the western white pines of the North Fork of the Flathead River on the Blackfeet National Forest. Losses were estimated at 25,000-30,000 board feet per acre. Similar conditions existed in the South Fork of the Flathead River where it was estimated that 500 million board feet of timber was killed (Evenden 1944).

A second outbreak occurred on the Blackfeet National Forest from 1918-1939. During 1918-1922, a severe infestation in lodgepole pine destroyed 75% and 90% of forested areas in Fortine Creek and Swamp Creek, respectively. In 1922, all mature lodgepole pine in this area were seriously infested, supporting MPB's northwestern expansion across Pinkham Ridge into the Kootenai National Forest (Evenden 1944). The Blackfeet National Forest reported that MPB outbreak activity declined to endemic levels across North Fork drainages of the Flathead River by 1929 (Evenden 1931).

In 1928, a severe infestation was reported in western white pine in Canyon and McGinnis Creeks. There were 7,560 attacked trees on 3,600 acres, totaling 2.1 infested trees per acre (Evenden 1930). Mortality continued until forest officers reported outbreak severity decreased in 1933 (Evenden 1934).

Supporting Documentation: Evenden 1928b; Evenden 1930; Evenden 1931; Evenden 1934; Evenden 1940; Evenden 1944

Cabinet National Forest

Outbreak Period: 1930-1949
Area Mapped: 4,758 acres
Species Impacted: western white pine and lodgepole pine

The Cabinet National Forest was created in 1907, then divided amongst the Kaniksu, Kootenai, and Lolo National Forests in 1954. Elevated MPB populations were reported in the Cabinet National Forest in 1930 (Evenden 1931). Approximately 13% of lodgepole pine stands located at the head of McGinnis Creek were colonized by 1932 then progressively decreased starting the following year (Terrell 1936).

From 1933-1942, a severe infestation in western white pine was recorded in Elk Creek and at the source of Cole and White Pine Creeks. Elk Creek saw decreasing infestations in 1936 whereas activity decreased in Cole and Trout Creeks by 1938 (Evenden 1936; Evenden 1937; Evenden 1938; Evenden 1939; Evenden 1941). A severe infestation was reported from the head of the Vermillion River in western white pine in 1941 which continued until 1949 (Evenden 1942; Evenden 1949).

Supporting Documentation: Evenden 1931; Evenden 1934; Evenden 1936; Terrell 1936; Evenden 1937; Evenden 1938; Evenden 1939; Evenden 1940; Evenden 1941; Evenden 1943; Evenden 1949

Coeur d'Alene National Forest

Outbreak Period: 1897-1913 & 1918-1945
Area Mapped: 70,278 acres
Species Affected: western white pine

The Coeur d'Alene National Forest was created in 1906, then was incorporated into the Idaho Panhandle National Forests in 2000 with the Kaniksu and St. Joe National Forests. A severe MPB infestation impacted the western white pines across the Forest from about 1897-1913 and again from 1918-1945 (Evenden 1926a; Evenden 1940; Evenden 1946).

In 1907, Coeur d'Alene National Forest Supervisor Skeels reported a 40-50% loss of western white pine to MPB infestations over the past decade (Evenden 1940). In his 1939 Annual Forest Insect Status Report for Idaho and Montana, Evenden commented on this early mortality estimate 32 years after it was made:

> *"Although this figure may appear high, many areas show comparable reductions in the original white pine stocking of mature trees. ...The many standing and fallen snags of trees killed by this insect remain in mute evidence of past losses"* (Evenden 1940, p. 4).

The severe outbreak in the early 1900s gave rise to the first control project implemented to directly control MPB in western white pine. In 1913, approximately 2,500 trees infested trees were felled and peeled to destroy brood across three treatment units (Evenden 1940).

From 1918-1923, 3.62% of the western white pines near Independence Creek were killed by MPBs. Infestations continued from 1924-1925 with annual losses of 0.5-1.0% of the total volume of this species present. The Cascade Creek drainage, located 10 miles south of Independence Creek, had infestations as well estimated at 14.1 board feet per acre. Control efforts were carried out in Independence Creek from 1924-1926 with the treatment of 60 trees (Evenden 1926a).

Subsequently, MPB activity expanded throughout the Forest in the late 1920s. The Coeur d'Alene Bark Beetle Control Project was implemented in nearly all locations with western white pines present 1930 when 23,000 trees were treated at a cost of $123,000. A 68% decrease in infested trees was reported from all treated areas. Another $15,000 was spent to apply additional control measures in October of 1930 (Evenden 1931). Operations were conducted annually, and reports documented decreased infestation rates following treatment (Evenden 1934).

During the spring of 1933, direct control treatments were reported on 8 units (including the Upper Cougar, Lower Cougar, Cabin Creek, Forks Steamboat, Clay Creek, Burnt Cabin, Honeysuckle, and Laverne Units) across 21,677 acres. In total, 4,552 trees were felled, peeled, and burned at a cost of $25,000. After annual surveying took place, managers determined that only units in the Cascade Creek drainage was in need of treatment. In October of 1933, 887 trees were decked and burned for about $9,000. In total, treatments resulted in a 52% drop in infested trees in 1934 (Evenden 1934).

The Yellow Dog River Unit saw heavy infestation from 1932-1941. Severe, continuous loss over several years led to mortality rates of western white pine being estimated at 50%. The Downey Creek Unit was also heavily infested from 1935-1941 with similar conditions in some other units. Infestations were more severe on north-facing slopes where grouped mortality centers were common. Trees with southern exposures were infested to a lesser degree as attacks were typically scattered. On some very dry sites, mortality rates of up to 75% of pines available within stands were killed by MPBs (Evenden & Terrell 1932; Evenden 1937a; Terrell & Evenden 1941).

In 1935, control efforts on Lower Flat Creek, Bennett Creek, Brett-Miner, Rocky City, Honeysuckle, Yellow Dog, Downey, and Sissons Units treated 3,017 trees on 10,838 acres for $15,535.60 (DFIIS 1938). Treatment was also conducted in Big Camp Creek where 69 infested trees were burned and 105 trees peeled (Bedard 1935). Road building in areas such as the Honeysuckle Unit led to MPB infestations in trees damaged during construction. Managers believed that beetles favored trees injured from construction which supported population amplification and attacks within adjacent, healthy trees (Bedard 1939).

By 1936, severity had decreased, and control measures were not warranted in most units. Managers felt that the Coeur d'Alene Bark Beetle Control Project had successfully impeded the development of a severe and widespread outbreak, prevented extensive loss of western white pine, and showcased a successful large-scale control effort (Evenden 1937).

While MPB activity was temporarily reduced, new infestations were initiated in additional locations in 1937, indicating benefits of direct control efforts were short-lived. Direct control management continued as 2,000 trees were felled and peeled or felled and burned on 1,749 acres in the East Fork of Steamboat Creek at a cost of $10,226.38 (DFIIS 1938). At least 600 infested trees remained following treatments as the control project was abandoned early due to stormy weather (Evenden 1939).

Additional 1937 control efforts occurred in the Taylors, Forks-Cabin, Clay Creek, Yellow Dog River, and Downey Units. In 1939, 9,056 white pine trees in the Coeur d'Alene National Forest were either felled and peeled, felled and burned, or peeled standing for a cost of $33,540 which did not count Civilian Conservation Corps labor (Evenden 1940). Control was not effective severe infestations persisted several areas (including the Sissons, Yellow Dog River, Yellow Dog Creek, and Downey Creek Units) until 1945 (Terrell & Evenden 1941; Evenden 1946).

Managers estimated that from 1929-1939 alone, 9 million board feet of western white pine, nearly 200,000 mature trees, were killed by MPBs across the Forest. They also noted that MPB impacts on younger stands was negligible and considered smaller and younger trees as non-susceptible host (Evenden 1940).

Supporting Documentation: Evenden 1926a; Evenden 1928; Evenden 1929; Evenden 1931; Evenden & Terrell 1932; Evenden 1934; Bedard 1935; Evenden 1936; Evenden 1937; Evenden 1937a; DFIIS 1938; Evenden 1938; Bedard 1939; Evenden 1939; Evenden 1940; Evenden 1940a; Terrell & Evenden 1941; Evenden 1942; Evenden 1943; Evenden 1946

Flathead National Forest

Outbreak Period: 1909-1917 & 1927-1945
Area Mapped: 23,549 acres
Species Impacted: Majority lodgepole pine with limited western white pine and ponderosa pine

The Flathead National Forest was created in 1897 and was expanded into the Blackfeet National Forest in 1935. Reports indicated MPB outbreak from 1909-1917 in lodgepole, western white, and ponderosa pine hosts during which severe timber losses occurred across the Forest (Evenden 1944).

From 1909-1913, an infestation of 20,000 trees was reported in western white pine host in the South Fork of the Flathead River drainage. This infestation was near another outbreak area in the northern portion Swan Lake area where lodgepole pines were impacted. Near Swan Lake, 30,000 infested lodgepole pines were detected in sections around the southern shore in 1911. Direct control treatments were instituted in 1912 when 28,000 trees were removed at a cost of $6,350. Control measures were considered successful in 1913, although the infested stands were small and isolated as they were surrounded by large, mature lodgepole pines attacked by MPBs in previous decades (Evenden 1944).

By 1917, severe infestations in lodgepole and ponderosa pine were common in the upper Swan River drainage. Forests were especially impacted south of Lion and Cedar Creeks, north of Seeley Lake, east of the Mission Mountain Range, and west of the Swan-Flathead Mountain Range. Severe outbreak centers were reported around the Anderson and Halpen homesteads, with a concentrated infestation measuring 6 miles wide and 20 miles long documented along the Swan River between Lion Creek and the Gordon Ranch. Timber loss in the upper Swan River area were estimated to cover 12% of all lodgepole pine and 5% ponderosa pine timber types in this area (Evenden 1944).

Beginning in 1927, MPB activity increased again with an outbreak in western white pine across the Krause Creek Basin (Evenden 1931). By 1933, severe infestations across susceptible lodgepole and western white pine host across the Forest. Numerous direct control projects were considered but did not occur due to the large area impacted and high treatment costs (Evenden 1934).

In western white pine forest types, including drainages throughout the South Fork of the Flathead River, MPB activity decreases began in 1935 (Evenden 1936). Reports indicated infestations within lodgepole pine stands had declined substantially in 1937 (Evenden 1938). However, in 1938 some infestations in both western white and lodgepole pine began to increase and spread through lodgepole pines throughout the Big River District (Evenden 1939).

In 1939, reports estimated that over the last 10-12 years, 80% of the volume of merchantable western white pine in the Canyon Creek drainage of the North Fork of the Flathead River was killed by MPBs (Evenden 1940). The outbreak throughout drainages of the South Fork of the Flathead River, reported during in the same time period, had similarly extensive losses. In both locations, infestations were considered to have run their course by 1945 (Evenden 1946).

Supporting Documentation: Evenden 1931; Evenden 1934; Evenden 1936; Evenden 1938; Evenden 1939; Evenden 1940; Evenden 1941; Evenden 1942; Evenden 1943; Evenden 1944; Evenden 1946

Glacier National Park

Outbreak Period:	1910-1913 & 1927-1942
Area Mapped:	16,048 acres
Species Affected:	lodgepole pine and western white pine

Glacier National Park was created in 1910, sharing its eastern border with the Blackfeet Indian Reservation, western border with the Blackfeet National Forest, and southern border with the Flathead and Lewis and Clark National Forests.

An early MPB outbreak occurred in the Park from 1910-1913 in western white pine stands surrounding Lake McDonald. This severe infestation covered 1,100 infested trees and early records reported success in direct control efforts that were implemented. Other locations with infestations occurred in this time period without treatment (Evenden 1930).

From 1927-1942, reports indicated an additional outbreak period occurred within the Park. Severe infestations were noted around Howe Ridge near the northwestern portion of Lake McDonald and across lodgepole and western white pine stands throughout the western portion of the Park. Following concern from managers and the public, Evenden (1931a) wrote:

> *"The epidemic will not completely destroy the scenic values of these forests, and such losses as do occur might well be considered as being but one of nature's methods to eliminate the old and to provide room for young and thrifty growing trees"* (Evenden 1931a, p. 8).

From 1928-1930, western white pine were reported infested in Spruce Creek at a rate of 7 infested trees per acre, ultimately depleting 80% of western white pines in the area. Similar reports identified greater than 60% of western white and lodgepole pines around Harrison Lake at a rate of 16 trees per acre (Evenden 1930).

In 1930 and 1931, control measures were instituted near McDonald Lake where over 3,000 infested lodgepole and western white pines were treated at a cost of $4,000. Specifically, in the McDonald-Mineral Creek basin, 363 western white pine were treated and only 25 trees were attacked the following year (Evenden 1930). Managers reported this as a successful control effort that reduced the number of infested trees by 93% (Evenden 1931).

In 1931, MPB activity spread to the east side of the park and control efforts occurred in the Sun Camp and Cutbank Districts. While these infestations contained few trees, managers were concerned due to the damage found on the west side (Evenden 1931a).

Decreasing MPB populations were reported on the west side of Glacier National Park from 1936 to 1939 in both lodgepole and western white pine stands (Evenden 1937; Evenden 1940). In 1941, a few infested western white pines were cut near Park Headquarters and Sprague Campground (Evenden 1942). By 1942, only a few trees were found to be infested across the park and the outbreak was over (Evenden 1943).

Supporting Documentation: Evenden 1930; Evenden 1931; Evenden 1931a; Evenden 1937; Evenden 1940; Evenden 1942; Evenden 1943

Kaniksu and Pend Oreille National Forests

Outbreak Period: 1924-1942
Area Mapped: 184,761 acres
Species Affected: western white pine

The Kaniksu National Forest was created in 1908 and incorporated additional acreage from the Pend Oreille National Forest in 1933. This Forest was then incorporated into the Idaho Panhandle National Forests in 2000 along with the Coeur d'Alene and St. Joe National Forests. MPB outbreaks for Pend Oreille and Kaniksu National Forests are combined for this writeup. Most locations reported MPB infestations of less than one tree per acre, however, due to the high timber quality and lower initial numbers of western white pine, managers indicated losses at that severity were substantial.

Severe outbreaks in the mid-twenties left behind stands in most areas with insufficient timber volume to justify either costs of control efforts or harvesting. Although most outbreaks reported had limited severity, by 1933, some areas within the Kaniksu National Forest had substantial infestations (Evenden 1934).

For example, by 1936, the Smith Creek drainage was heavily infested by MPBs causing considerable timber losses. Control efforts were implemented in 1937, with the treatment of 377 trees (Evenden 1938). Hazardous fire conditions ultimately shut down the control project, leaving 75 infested trees untreated; however, surveys the following season reported an 87% reduction in number of infested trees (Terrell & Evenden 1938c).

Severe infestations were also reported in the Rapid Lightning and Lost Creek drainages in 1937. By 1939, the western white pine stand in Rapid Lightning Creek had suffered losses amounting to 2.03% of all species timber volume present (Evenden 1941).

Supporting Documentation: Evenden 1931; Evenden 1934; Evenden 1936; Evenden 1937; Evenden 1937a; Evenden 1938; Terrell & Evenden 1938c; Evenden 1940; Evenden 1940a; Evenden 1941; Evenden 1942; Evenden 1943

Kootenai National Forest

Outbreak Period: 1915 & 1925-1945
Area Mapped: 65,721 acres
Species Affected: western white pine & lodgepole pine

The Kootenai National Forest was created in 1907 and incorporated additional area from the Blackfeet National Forest in 1935 and from the Cabinet National Forest in 1954. A short-lived MPB infestation was reported in 1915 and severe and widespread outbreak from 1925-1945 (Evenden 1925a; Evenden 1928b; Evenden 1944).

The severe outbreak was first reported in western white and lodgepole pines in the northern drainages of the Yaak River from 1925-1927. In 1928, the Upper West Fork of the Yaak River and Garver Creek, were had solid blocks of red lodgepole pines throughout the Garver Creek and northern Yaak River drainages. Reports indicated MPBs killed many thousands of lodgepole pines and was rapidly expanding southward in the late-1920s. Severe damage levels were reported into Canada as well (Evenden 1928b; Evenden 1944).

Control efforts were instituted in Pete Creek on the Upper Yaak River in the spring of 1926 and 1927 to experiment with protecting western white pine from MPB attacks. Treatments were considered ineffective as beetles from large blocks of infested lodgepole pines to the south infested western white pines where management occurred. Direct control efforts were abandoned in 1928 after surveys identified severe infestations throughout the adjacent forests (DFIIS 1929).

Fire-injured white pine trees left behind by an intense 1925 burn in the Pipe Creek area were heavily attacked in 1926. From 1926-1928, MPBs caused 20-30% western white pine loss in the area. A MPB outbreak was reported occurred in the Pipe Creek area about 12-15 years prior which left thousands of gray snags. With so much damage, managers questioned whether the remaining volume of the stand held even 15% of its original western white pine component by 1928 and losses continued as 1,200 newly infested trees were reported that year (Evenden 1928b).

Six infested units with western white pine on the Kootenai National Forest were treated under control measures instituted in the fall of 1929 and spring of 1930. After treating 4,303 trees at a cost of $20,640, surveys in the fall of 1930 found an average decrease of 82% in the infested trees in treatment units. However, treatments were only partially successful as reduced levels of MPB infestation continued in treated areas (Evenden 1931). By 1934, infestations throughout mature western white pine resulted in heavy losses throughout the Forest (Evenden 1940).

Control efforts continued from 1933-1934 where managers aimed to protect high-value western white pines. Reports in 1933 described felling and burning 908 trees in three small western white pine stands covering 3,986 acres in the Lower Keeler, Stanley, and Spread Creek treatment units for $3,571. In 1934, in the Pete, Bristow, and once again, Spread Creek units, 2,040 trees where either decked and burned or peeled over 4,389 acres for a cost of $9,368.10. Additionally, 920 trees were hand-logged and burned from 5,344 acres in the Star, Benning, and Meadow Creek units for a total of $7,540.99 (DFIIS 1938).

Fall 1935 surveys showed MPB were present in every western white pine stand sampled across the Forest (Evenden 1936; Evenden 1938). Infestations continued in the Madge, Benning, Lower Keeler, North Keeler, and Star Creek treatment units through the late thirties (Terrell & Evenden 1938a).

Control measures were implemented in the Benning Creek Unit in 1939 and deemed unsuccessful after the infestation continued into 1940. Direct control was considered successful in the Lower Keeler Creek unit area where 1938 treatments decreased infested trees per acre from .933 to .303 in 1939 and subsequent surveys in 1940 reported minimal infestated trees. Similar reductions in MPB activity occurred after treatments in the North Keeler Creek unit (Terrell & Evenden 1938a).

The heavily impacted Spread Creek unit reported decreased infestation levels in 1938 (Terrell & Evenden 1938a). Subsequently, an additional outbreak was initiated in fire-injured trees following the Spread Creek Fire in 1940. MPB attacks occurred both within fire-injured trees as well as than 100 green trees located beyond the fire boundary. Direct control occurred through a sanitation harvest in 1941 when 95% of infested trees were removed (Evenden 1942).

Both the Pete and Spread Creek units lost a substantial volume of western white pine around 1930, which was hindered by direct control measures. At least 60% was lost in the Pete Creek Unit, while the Spread Creek numbers where lower. By 1945, these infestations had built up enough to jeopardize the remaining timber and, in May, control efforts treated 983 severely infested trees (Evenden 1946).

Entomologists reported the MPB infestation of western white pine throughout the Kootenai National Forest was comparable to the extent of damage reported throughout the Coeur d'Alene National Forest. Managers concluded direct control efforts reduced pine losses where treatment were able to reduce large proportions of infested trees (Evenden 1934).

Supporting Documentation: Evenden 1925a; Evenden 1928b; DFIIS 1929; Evenden 1934; Evenden 1936; Evenden 1937; DFIIS 1938; Evenden 1938; Terrell & Evenden 1938a; Bedard 1939; Evenden 1939; Evenden 1940; Terrell 1940; Evenden 1941; Evenden 1942; Evenden 1943; Evenden 1944; Evenden 1946

Lewis and Clark National Forest

Outbreak Period: 1945-1949
Area Mapped: 4,344 acres
Species Affected: ponderosa pine

The Lewis and Clark National Forest was created in 1897 and incorporated the entire Jefferson National Forest in 1932. MPB infestations were reported in ponderosa pine stands from 1945-1949 at low levels (groups of 1-6 trees) (Evenden 1946; Evenden 1949a). Infestations were reported to have decreased in severity by 1947 (Evenden 1946).

Supporting Documentation: Evenden 1931; Evenden 1934; Evenden 1946; Evenden 1949a

St. Joe National Forest

Outbreak Period: 1930-1945
Acres Mapped: 4,721 acres
Species Affected: western white pine and lodgepole pine

The St. Joe National Forest was created in 1908 and was incorporated into the Idaho Panhandle National Forests in 2000 along with Coeur d'Alene and Kaniksu National Forests.

In 1930, a severe western white pine outbreak was reported in the Simmon's Creek drainage. By 1933, lodgepole pine in the area was also being attacked (Evenden 1931; Evenden 1934). Severe lodgepole pine infestations were also reported on Turner Flat in 1930 with substantial damage found in 1935 near Ward's Peak. Western white pine mortality also occurred throughout the Turner Flat creek during this time period (Evenden 1931; Terrell & Evenden 1938).

Multiple units in the late-1930s were surveyed to estimate MPB activity. The Clarkia Unit was the most heavily infested on the St. Joe National Forest in 1937 with low mortality rates where 0.51% of the western white pine stand was impacted (Terrell & Evenden 1938). From 1937-1938, MPB attacks of western white pine increased along the St. Joe River and near Fishhook Creek (Evenden 1938).

Most surveys after 1940 found endemic conditions, although a severe outbreak was reported in the Siwash Creek drainage in 1945. Additionally, limited infestations that ranged up to 0.8% stand mortality were identified in the Fleming, Sisters, Boulder, Stub Toe, and Montana Creek drainages (Evenden 1946).

Supporting Documentation: Evenden 1931; Evenden 1934; Evenden 1936; Evenden 1937; Evenden 1938; Terrell & Evenden 1938; Evenden 1939; Evenden 1940; Evenden 1941; Terrell 1941; Evenden 1942; Evenden 1943; Evenden 1946

National Forests within Central Section of the Northern Region

Lolo National Forest

Outbreak Period: 1930-1938 & 1945-1948
Area Mapped: 43,082 acres
Species Affected: lodgepole pine, western white pine, and ponderosa pine

The Lolo National Forest was created in 1906 and received area from the Missoula National Forest in 1931, the Selway National Forest in 1934, and the Cabinet National Forest in 1954. In 1930, the first MPB reported activity occurred within western white pines in the Twelve Mile Creek drainage (Evenden 1931). From 1933-1938, lodgepole pine stands throughout the Forest were attacked. Reports estimated as many as 70% of lodgepole pine stands were lost over this time period (Evenden 1939). Managers believed these infestations occurred following spread from Forests to the south (Evenden 1934).

Control efforts were implemented in the Big Creek and Twelve Mile Creeks in 1935. Road-building in 1933/1934 had apparently contributed to the infestation, as slash piles and surrounding trees were infested. Specifically, in the Twelve Mile Creek and Big Creek drainages, 242 trees and 56 trees were respectively treated (Evenden 1935). Low winter temperatures during 1935 assisted control efforts and were reported to have substantially decreased overwintering brood populations and control measures were discontinued (Evenden 1937).

Light, scattered ponderosa pine infestations were reported near Seeley Lake in the Trail and Fish Creek drainages in 1945 (Evenden 1946). In 1948, the Up Up Creek unit reported a severe but isolated lodgepole pine infestation throughout the drainage (Evenden 1949).

Supporting Documentation: Evenden 1931; Evenden 1934; Evenden 1935; Evenden 1936, Evenden 1937; Evenden 1938; Evenden 1939; Evenden 1940; Evenden 1946; Evenden 1949

Beaverhead National Forest

Outbreak Period: 1911-1913 & 1924-1938
Area Mapped: 845,195 acres
Species Affected: lodgepole pine and whitebark pine

The Beaverhead National Forest was created in 1908 and combined with the Deerlodge National Forest in 1996. This Forest had the most extensive mortality of all Forests in R1 during the 1909-1945 outbreak period. Much of the infestation was located within and surrounding the Big Hole Basin, but spread throughout this and adjacent Forests, impacting an estimated area of 1,341,860 acres (Evenden & Gibson 1940, pg. 273).

From 1911-1913, there were reports of a substantial infestation 35 miles long and 2-4 miles wide on the northwest side of the Big Hole Basin with 34,000-43,000 infested lodgepole pine. Some attacked groups contained groups of 2,000 infested trees (Evenden & Gibson 1940; Evenden 1944). Control efforts began in 1912, with the felling and peeling of infested trees, however, this method was soon replaced with peeling standing trees to a height of 12 feet. From 1912-1913, 25,719 trees were treated at a cost of $9,534 (Evenden 1944). Treatments were considered successful after very little infestation was found in 1914. Endemic MPB populations persisted for the subsequent decade.

Extensive outbreaks within the East Fork of the Bitterroot River on the Bitterroot National Forest, and on the Salmon National Forest, were believed to be the sources of MPB populations that spread to colonize the Beaverhead National Forest from 1924-1938 (Evenden & Gibson 1940; Evenden 1944). During this time, a severe MPB outbreak spread throughout the range of lodgepole pine located across the Forest. An estimated 57,756,000 trees greater than 3 inches d.b.h. were killed, with a loss of approximately 77% of pines ≥ 9 inches d.b.h (Evenden 1931; Evenden & Gibson 1940).

The Forest's infestation began on the west side of the Big Hole Basin in 1924. In 1925, a light infestation was unsuccessfully treated by a forest management crew in an effort to prevent a serious outbreak. Additional control efforts on the west side of the Big Hole Basin occurred from 1926-1928; however, efforts did not prevent infestations from growing. During this time period, 77,771 trees were treated on 103,800 acres for a cost of $141,887. MPBs reinfested treatment units from adjacent stands each year and the outbreak progressed across the Continental Divide then further south and east (Figure 4; Evenden & Gibson 1940, Evenden 1944).

Direct control treatments continued as MPBs spread to the east side of the Big Hole Basin. As with the west side management, efforts were unsuccessful at impeding the outbreak event as reinfestations were common in treated units. Control measures were quickly discontinued due to cost and likelihood of failure (Evenden & Gibson 1940; Evenden 1944). Each passing year resulted in increased severity and surveys reported infestation rates from 10 to 59 trees per acre (Evenden 1931; Gibson 1936).

In 1932, MPBs were estimated to have killed 17,586,000 trees in the Forest (Evenden & Gibson 1940). An extreme weather event during the winter of 1932/1933 caused substantial MPB brood mortality due cold temperatures. This resulted in sustained population reductions in some areas while in others, especially where sufficient mature lodgepole pine host remained, MPB populations increased in 1934. In the 1934/1935 winter, a second cold event was reported to have caused additional MPB brood mortality and was attributed to have stopped outbreaks in many Forest locations (Evenden 1934; Evenden & Gibson 1940).

Supporting Documentation: Gibson 1930; Evenden 1931; Evenden 1934; Gibson 1936; Evenden & Gibson 1940; Evenden 1944

Bitterroot National Forest

Outbreak Period: 1913-1940
Area Mapped: 132,014 acres
Species Affected: lodgepole pine and ponderosa pine

The Bitterroot National Forest was created in 1906 then received additional acreage from the Selway National Forest in 1911. Beginning in 1913, the Bitterroot National Forest experienced a severe MPB outbreak, particularly in the East Fork area of the Bitterroot River. This outbreak was discovered at the head of the East Fork during a 1921 survey (Evenden 1944). The survey estimated lodgepole pine infestation rates in the Martin and Moose Creek drainages at 20% and 30%, respectively, and MPBs reached epidemic population levels and caused severe and widespread mortality by 1923 (Evenden 1921; Rust & Evenden 1924).

Reports from 1923 surveys indicated entire mountainsides were red with solid blocks of infested trees. Nearly all green lodgepole pine measuring ≥ 10 inches d.b.h. were attacked with groups of ponderosa pine ranging from 10-20 infested trees occurred on adjacent ridges. In 1924, surveys estimated at least 150,000 infested trees in the East Fork of the Bitterroot River and infestation rates increased from 100-1000% the following year. In the Bertie Lord drainage alone, reports listed 8,000 infested trees (Rust & Evenden 1924; Evenden 1925).

The source of substantial MPB populations from 1924-1925 was debated as some entomologists believed local buildups occurred since 1913 while others indicated population migration from MPB populations from forests impacted to the northeast (Rust & Evenden 1924).

In 1925, an imaginary boundary line was placed across the East Fork of the Bitterroot River to curb infestation growth. Control measures aimed to treat all infested trees west of this line with $8,000 of funding secured for treatment efforts. Direct control occurred and treatments were ineffective as treated areas were re-infested and late-summer surveys found severe infestations occurred several miles downriver. Managers acknowledged that 'defense-line' and 'advance-spot' control measures were generally ineffective with large-scale outbreak events (Evenden 1944).

Smaller plans for control were executed during the spring of 1926, as well as in 1927, with a few thousand dollars spent to treat an infested area along the southern edge of the Bitterroot National Forest. An additional $5,000 was spent to treat 1,244 infested trees located in front of the large-scale infestation center advancement. This treatment was overall ineffective as only a small percentage of infested trees were treated and beetles consistently migrated across control lines. Eventually, management decision was made to halt further direct control efforts on the Bitterroot National Forest (Evenden & Gibson 1940; Evenden 1944).

In the late 1920s, MPB populations progressed through lodgepole and whitebark pines, across low-lying portion of the Continental Divide, into the western edge of the Pintler Unit of the Beaverhead National Forest. This contiguous expanse of susceptible host continued southwest and provided a migration corridor from the Bitterroot River directly into the Big Hole Basin (Gibson 1930; Evenden 1944).

MPB activity continued to cause impacts in pines across the Bitterroot National Forest until 1934 when populations started to decline. Overall outbreak was considered to have subsided by 1940 (Evenden & Gibson 1940; Evenden 1941; Evenden 1944).

Supporting Documentation: Evenden 1921; Rust & Evenden 1924; Evenden 1925; Evenden 1928a; Gibson 1930; Evenden 1931; Gibson 1936; Evenden 1940; Evenden 1941; Evenden & Gibson 1940; Evenden 1944; Mary Williams, Retired Bitterroot National Forest Historian.

Clearwater National Forest

Outbreak Period: 1927-1945
Area Mapped: 13,915 acres
Species Affected: western white pine and lodgepole pine

The Clearwater National Forest was created in 1908 and combined with the Nez Perce National Forest in 2012. Reports indicate MPB activity initiated in 1927 within western white pine host. Site-specific locations were surveyed and some had isolated trees attacked by MPBs while others had severe infestations that persisted for over a decade. Private lands owned by the Clearwater Timber Protection Association were also infested and survey and control activities coordinated by the Bureau of Entomology (Balch 1929; Evenden 1931).

The Teepee Creek area had severe infestation where groups of 4-5 MPB-infested western white pines were found (Terrell & Evenden 1938b). Some lodgepole pine was also infested, namely in Shanghai, Orogrande, and Silver Creeks (Terrell & Evenden 1938b; Evenden 1943). These infestations were noted as being severe. For example, the Shanghai Creek drainages contained large groups of infested trees with multi-year losses occurring across nearly all Lodgepole pine present over a ten-year period. Reports documented that damage caused by road construction contributed to infestations. Specifically, in the Cedars Unit, 75 western white pine trees were found infested immediately adjacent to Kelly Creek Road (Terrell & Evenden 1938b).

Information on location and efficacy of direct control treatments implemented was limited to a few locations. Near the Musselshell Ranger Station, direct control by peeling and burning methods 575 western white pine trees that were infested after spring blow-down event. This treatment had total cost of $3,450 and the number of infested trees was reduced by 90% post-treatment (Evenden 1931). Subsequently in 1939, 3,031 infested western white pines were treated across the Forest and Clearwater Timber Protection Association lands at a cost of $21,973 (Evenden 1940).

Supporting Documentation: Balch 1929; Evenden 1931; Evenden 1934; Evenden 1936; Evenden 1937; Evenden 1938; Terrell & Evenden 1938b; Evenden 1940; Evenden 1941; Evenden 1942; Evenden 1943; Evenden 1946

Deerlodge National Forest

Outbreak Period: 1921-1938
Area Mapped: 512,508 acres
Species Affected: lodgepole pine

The Deerlodge National Forest was created in 1908 and combined with the Beaverhead National Forest in 1996. The Forest bordered the heavily infested Beaverhead National Forest.

All Ranger Districts in the Forest reported MPB infestations distributed throughout virtually all mature lodgepole pine stands and considerable timber losses (Evenden 1931; Evenden 1938; Evenden 1939). In 1921, the total loss of timber was conservatively estimated at 10 million board feet from over 63 square miles or sections (Rust & Evenden 1922). Direct control efforts occurred in isolated areas to protect high-value resources. For example, in the Fishtrap Creek area, reports indicated 59 of 67 severely infested trees were treated in 1925 (Taylor 1925). Infestations continued until 1937 when reports indicated severity decreased substantially with none being considered as ‘serious’ as of 1938.

Supporting Documentation: Rust & Evenden 1922; Taylor 1925; Evenden 1931; Gibson 1936; Evenden 1938; Evenden 1939; Evenden 1944

Helena National Forest

Outbreak Period: 1916-1938 & 1942-1944
Acres Mapped: 291,247 acres
Species Affected: lodgepole pine and ponderosa pine

The Helena National Forest was created in 1906. From 1916-1921, severe MPB infestations were reported in lodgepole pines throughout the Lincoln Basin from the headwaters of the Blackfoot River to forests surrounding Lincoln, MT (Evenden 1944). This Lincoln area outbreak originated from the southward expansion of MPBs that infested the Seeley Lake area on Missoula National Forest. By 1921, the Lincoln area was estimated to contain millions of trees killed by MPBs (Evenden 1944).

MPBs spread south from Lincoln, along both sides of the Continental Divide throughout the southern portions of the Clark Fork River until contiguous infestations occurred throughout 80 sections or 80 m2. In 1922, reports provided a conservative estimation 22.5 million board feet lost to the MPB outbreaks. Forested areas immediately adjacent to the Forest recorded additional losses of 56.3 million board feet (Rust & Evenden 1922).

Control measures were instituted in the most heavily infested areas in 1923 with some reporting effective results. For example, eighty-four trees were treated in Red Gulch, and Hunter's Gulch which led to a 94% reduction in attacked trees the season following treatment (Evenden 1923; Rust 1923). Treatments were limited to peeling bark to a height 5-feet above ground-level within standing infested Lodgepole pines with axes and bark spuds. Managers reported that woodpeckers contributed to considerable MPB larvae mortality directly through predation and indirectly by promoting brood desiccation. Where this was noted control efforts were curtailed (Evenden 1923; Rust 1923).

While minimal relative to the lodgepole pine infestation, the Lincoln Basin was one of the few areas where severe ponderosa pine mortality occurred from MPB-attacks. It was reported that infestations occurred both in the early 1920s (causing up to 40% volume losses in merchantable pines) as well as from 1942-1944 (causing mortality in 8,000 ponderosa pines or 5 million board feet of timber) (Evenden 1946). The Avon Valley had similar MPB outbreak activity in ponderosa pine hosts with slightly less volume lost relative to the Lincoln area (Evenden 1946).

Supporting Documentation: Evenden 1923; Rust 1923; Evenden 1931; Evenden 1934; Evenden 1936; Evenden 1938; Evenden 1939; Evenden 1944; Evenden 1946

Jefferson National Forest

Time Period: 1909 & 1930
Area Mapped: 20,422 acres
Species Affected: lodgepole pine and ponderosa pine

The Jefferson National Forest was created in 1908 and the entire forest was transferred to Lewis and Clark National Forest in 1932. In 1909, an extensive MPB infestation was reported in lodgepole pine by Josef Brunner while hunting in the Little Snowy Mountains (Furniss & Renkin 2003; Furniss 2007). A limited ponderosa pine infestation was reported in 1930 in the Dry Wolf Comb Sage Creek area (Evenden 1931).

Supporting Documentation: Evenden 1931; Furniss & Renkin 2003; Furniss 2007

Missoula National Forest

Time Period: 1912-1930
Area Mapped: 267,418 acres
Species Affected: lodgepole pine

Missoula National Forest was created in 1907 then divided between the Lolo and Deerlodge National Forests in 1931. From 1912-1930, severe MPB infestations occurred in several locations across the Forest (Evenden 1931; Evenden 1944).

In 1912, there were reports of scattered MPB activity throughout the Seeley Lake area, with a center of 1,000 infested lodgepole pine located just west of Rainy Lake. In 1913, an estimated 100,000 infested trees on 15,000 acres were recorded west of Rainy, Inez, and Seeley Lakes. By 1914, an estimated one million lodgepole pine were under attack across the entire area and by 1916, reports estimated that 3.5 million trees were killed following severe MPB outbreaks (Evenden 1944). The infestation occurred in the Clearwater River drainage near Seeley Lake where abundant groups of MPB-killed pines, ranging from 20-100 trees per group, were visible along primary roadways. Reports described extensive sections of red and dead lodgepole pines, some spanning multiple thousands of acres, in which the vast majority of large pines were killed (Evenden 1944).

The Monture Creek drainage, located a few miles east of the Clearwater drainage, as well as numerous tributary drainages, experienced heavy mortality rates in large pines by 1914. Infested areas spanned throughout majority of the Blackfoot River watershed, from Gold Creek to Monture Creek, in lodgepole pine forests within over 20 townships (Evenden 1931; Evenden 1944). The Seeley Lake and Monture Creek infestations declined in severity from 1917-1921.

From 1914-1924, the bulk of the Blackfoot River outbreak had advanced southward along the west side of the Continental Divide (Rust & Evenden 1924). In 1923, groups of infested trees, ranging from 5-25 trees per group, spread throughout this area (Evenden 1924). Direct control efforts treated 1,010 infested trees in this drainage at a cost of $826.00. Treatments were deemed unsuccessful primarily due to difficulty in finding infested trees. Surveyors used red crowns from 1922-attacked pines to direct search efforts which missed substantial numbers of 1923-attacked tree groups. By early 1924, infestation spread continued and the Boulder Creek drainage just northeast of Philipsburg was the epicenter of a severe infestation where thousands of lodgepole pines were infested by MPBs (Evenden 1924; Rust & Evenden 1924; Evenden 1944).

In 1924, the ‘Barrier Plan of Control’ strategy was implemented in the Philipsburg Basin of the Missoula National Forest to stop geographic progression of MPBs to susceptible pine forests to the north. Managers created a line that extended west from Silver Lake to the Bitterroot River on the Bitterroot National Forest, crossing the Continental Divide between Stony and West Fork Rock Creeks in which direct control efforts would be coordinated to effectively stop MPBs from crossing the line. They aimed to ensure north of the line was a “No Bugs Land,” by treating all infested trees while MPB were migrating south past the defense line. late season survey revealed that the beetles had already entered “No Bugs Land” even before the southern quarantine implementation plan was started and large-scale direct control efforts were cancelled (Rust & Evenden 1924; Evenden 1944).

The Rock Creek drainage was another severely infested area of the Missoula National Forest, beginning in 1923. Near Copper Creek, 177,000 red lodgepole pine were recorded following multiple years of MPB outbreak activity. Managers believed the outbreak spread from MPB crossing over from the East Fork of the Bitterroot River previously (Rust & Evenden 1924; Evenden 1928a). In 1927, 67,000 dead lodgepole in the Willow Creek area were reported and managers believed MPB populations spread northern portions of the Missoula National Forest (Evenden 1928a).

Further surveys in 1927 found 376,109 attacked trees throughout the Rock Creek drainage, and managers expected that number to increase to at least 1,000,000 during the 1928 season (Evenden 1928a). With the

Bitterroot infestation providing a nearby source, re-infestation continued until 1930 when mature lodgepole pine host resources were depleted (Evenden 1931).

Supporting Documentation: Rust & Evenden 1922; Flint & Gisborne 1923; Evenden 1924; Rust & Evenden 1924; Evenden 1928a; Evenden 1931; Evenden 1944

Nez Perce National Forest

Outbreak Period:	1926-1937
Area Mapped:	9,658 acres
Species Affected:	lodgepole pine, ponderosa pine, whitebark pine, and western white pine

The Nez Perce National Forest was created in 1908 and combined with the Clearwater in 2012. The loss of timber attributed to the MPB infestation present on the Nez Perce National Forest from 1926-1937 was tremendous. Managers estimated that millions of board feet of ponderosa pines and at least a billion board feet of lodgepole pine were destroyed during this outbreak period (Evenden 1938).

Forest Supervisor Phillip's 1937 report letter to the Regional Forester stated:

> *"It is probably after all analogous to the old story of not being able to see the forest for the trees, and although we are spending thousands of dollars annually in fire prevention, presuppression, and firefighting, the fact remains that the loss from insects over any ten-year period has been many times greater than from fire"* (Evenden 1938, p. 2).

Reports documenting MPB outbreak activity were scarce relative to some other Forests and underestimated the spatial extents of MPB infestation mapped during this outbreak period.

Supporting Documentation: Evenden 1931; Evenden 1936; Evenden 1938

Selway National Forest

Outbreak Period:	1930-1933
Area Mapped:	6,399 acres
Species Affected:	lodgepole pine and western white pine

The Selway National Forest was created in 1911 and divided among the Bitterroot, Lolo, Clearwater, and Nez Perce National Forests in 1934. MPB infestations were first reported in 1930 throughout the Moose Creek District and near the Lochsa River in the Forest. Both lodgepole and western white pine were attacked and managers reported lodgepole pines had greater infestation impacts within locations surveyed (Evenden 1931; Evenden 1934).

Supporting Documentation: Evenden 1931; Evenden 1934

National Forests and Parks in Southeast Section of the Northern Region

Absaroka National Forest

Outbreak Period: 1930-1938
Area Mapped: 18,671 acres
Species Affected: whitebark pine and lodgepole pine

The Absaroka National Forest was created in 1908 and divided among Lewis and Clark and Gallatin National Forests in 1945. From 1930-1938, indicated severe MPB infestations began in whitebark pine stands and spread throughout adjacent lodgepole pine hosts (Evenden 1938). Infestations rates increased until 1936 then started to decline. By this point, the Forest Supervisor wrote the he believed virtually all susceptible whitebark pine and lodgepole pines would be killed during the outbreak (Evenden 1937).

Supporting Documentation: Evenden 1931; Evenden 1937; Evenden 1938; Evenden 1939

Beartooth National Forest

Outbreak Period: 1930
Area Mapped: 2,861 acres
Species Affected: lodgepole pine

The Beartooth National Forest was created in 1908 and divided among Absaroka and Custer National Forests in 1932. In 1930, an isolated MPB infestation was reported in Basin Creek (Evenden 1931). No further reports from this area occurred.

Supporting Documentation: Evenden 1931

Gallatin National Forest

Outbreak Period: 1930-1938
Area Mapped: 104,787 acres
Species Affected: whitebark pine and lodgepole pine

The Gallatin National Forest was created in 1899 and combined with the Custer National Forest in 2014. From 1930-1938, MPB infestations were reported throughout the Forest in lodgepole pines and throughout high-elevation whitebark pines. MPB host preference varied greatly between years and units surveyed; however, whitebark pine was reported to have sustained 2-times greater mortality relative to lodgepole pine, even though whitebark pine was distributed across substantially less area relative to lodgpeole pine hosts (Gibson 1934).

For example, in 1934 the Mill Creek Unit in the Tobacco Root Mountains, surveys estimated 66,140 lodgepole and 179,750 whitebark pines infested by MPB (Gibson 1935). The Miner Creek Unit near the northern border of Yellowstone National Park tracked infested trees from 1931-1934 across both hosts. Infested trees found in surveys included: 1,172 lodgepole pines vs. 257 whitebark pines in 1931; 1,842 lodgepole vs. 10,718 whitebark in 1932; 1,326 lodgepole vs. 6,144 whitebark in 1933; and 2,875 lodgepole vs. 34,125 whitebark in 1934 (Gibson 1934; Gibson 1935).

While MPB infestations declined across the adjacent Beaverhead National Forest from a cold-induced brood mortality event during the 1932/1933 winter, infestation rates of whitebark pines in the Gallatin National Forest suggested cold temperatures did not adversely impact MPB outbreaks as infestations typically increased from 1932 to 1933. Some reports suggested MPB activity in lodgepole pine hosts declined in some limited areas following this cold event. In the end, entomologists reported MPB outbreaks were eventually checked by substantial reductions in suitably sized host trees (Gibson 1934; Gibson 1935; Evenden & Gibson 1940).

Supporting Documentation: Evenden 1931; Evenden 1934; Gibson 1934; Gibson 1935; Gibson 1936 Evenden 1939

Madison National Forest

Time Period: 1928-1934
Area Mapped: 55,031 acres
Species Affected: lodgepole pine and whitebark pine

The Madison National Forest was created in 1907 then divided among the Beaverhead, Gallatin, and Deerlodge National Forests in 1931. A severe MPB infestation occurred in the lodgepole pine and whitebark pine stands within the Forest from 1928-1934. In 1930, 26,000 infested lodgepole were reported 35 miles from the closest MPB populations in the Beaverhead National Forest. Managers believed this provided evidence of long-range MPB dispersal across a vast treeless area between the two Forests as there was no evidence of buildup of local MPB populations (Evenden 1931).

In 1931, the Madison Insect Control Project was implemented with cut and burn or burned-standing techniques that treated 5,870 trees across 16,234 acres at a cost of $22,977 (De Jarnette 1931). Two units in the greater control project were the heavily infested Sheep Creek Canyon and Blacktail Units which were treated to protect valuable timber to the south (Evenden & Gibson 1940). Over 4,851 trees across 13,240 acres were cut and burned in these units (De Jarnette 1931). Treatment in these units occurred with treatments of all other known infested areas to the east to prevent MPB outbreak expansion. Management efforts were unsuccessful as rates of infestation increased post-treatment (Evenden & Gibson 1940).

MPBs continued to spread southeast across the Forest and control measures were discontinued. However, the extreme cold event during the winter of 1932/1933 was documented to have caused substantial brood mortality in the Sheep Canyon and Blaktail Deer infestation areas and mortality rates were reduced by 91.6% and 61.2%, respectively (Gibson 1934a; Evenden & Gibson, 1940).

Supporting Documentation: De Jarnette 1931; Evenden 1931; Gibson 1934; Gibson 1934a; Gibson 1935; Evenden & Gibson 1940; Evenden 1944

Yellowstone National Park

Outbreak Period: 1925-1940
Area Mapped: 187,782 acres
Species Affected: whitebark pine, lodgepole pine, and limber pine

Yellowstone National Park was created in 1872 and housed extensive lodgepole and whitebark pine forests in the early 20th century. Park managers were concerned about the potential for impacts to Park aesthetics from severe MPB infestations (Furniss & Renkin 2003).

In 1925, outbreaks of MPB were discovered in the whitebark pine forests in the Park near Mount Washburn which prompted treatment of 42 infested trees that were felled and burned. This infestation continued in subsequent years and eventually led to high mortality rates across the majority of the Park's mature whitebark pine. Numerous younger trees were documented to have pitched out attacking MPBs and were considered to have sufficient vigor to survive the outbreak (Furniss & Renkin 2003). Along with mortality in whitebark pines, lodgepole pine infestations occurred as well especially when they were in close proximity to whitebark pine infestations (Evenden 1939; Evenden 1944).

In 1930, reports documented lodgepole pine infestation of 3,000 trees in the southwest corner of the Park which likely originated from infestations on the Targhee National Forest (Evenden 1931; Evenden 1944).

Subsequently, the Park conducted extensive direct control treatments as part of the large-scale Yellowstone Bark Beetle Control Project. Treatment methods included felling and burning as well as burning-standing techniques. The operation covered units on the Beaverhead, Madison, and Gallatin National Forests, as well as in Idaho National Forests that surrounded the Park (Evenden 1931b; Furniss & Renkin 2003).

In 1931, 2,888 trees were treated on 12,344 acres of the Park for a cost of $7,767. Plans were to expand efforts in 1932 to treat 43,999 trees across 117,826 acres at a total cost of $110,000. This plan was the only bark beetle control project ever to have been proposed to the President of the United States for approval. However, the project was never approved through executive order and extreme winter temperatures in 1932/1933 caused extensive declines in beetle populations (Evenden 1931b, Evenden 1944; Furniss & Renkin 2003).

Supporting Documentation: Evenden 1931; Evenden 1931b; Gibson 1935; Evenden 1937; Evenden 1939; Evenden 1941; Evenden 1944; Furniss & Renkin 2003

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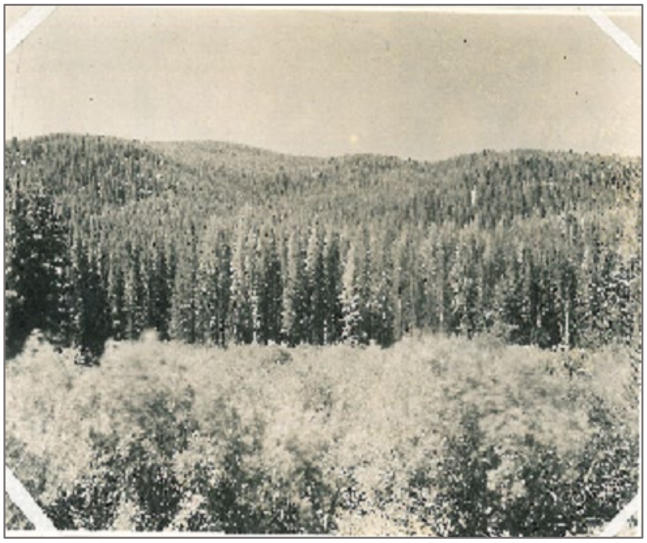
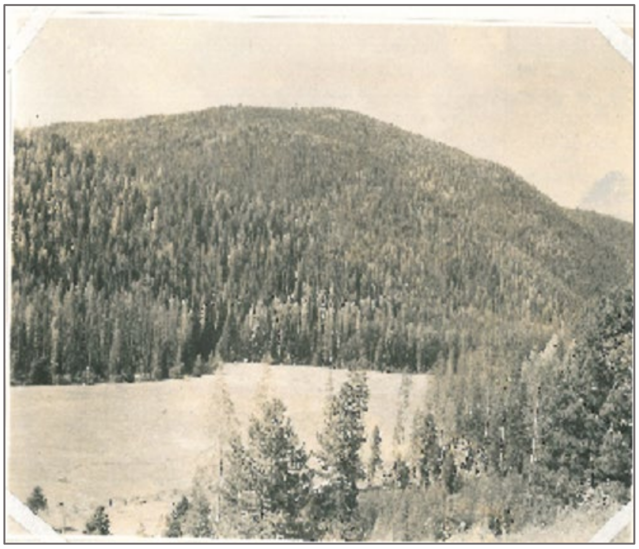
Appendix A

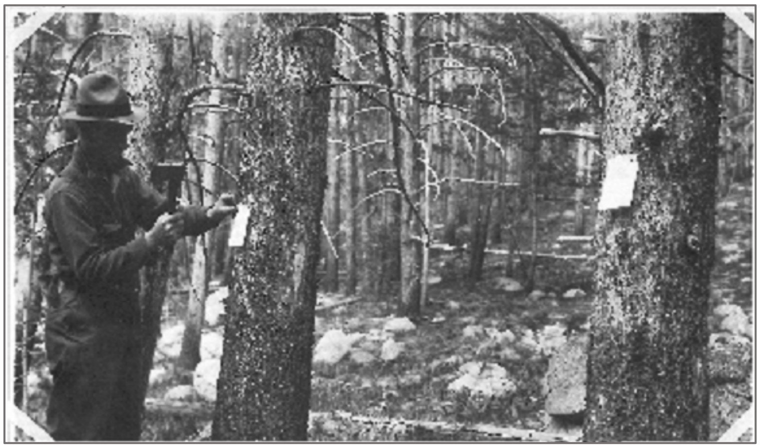
Photo essay. Progression of direct control treatment implementation for the Big Hole Basin Insect Control Project
Source: photos and historic captions from Evenden (1927)



Picture 1. "Mountain pine beetle infestation in the lodgepole pine stands on the East Fork of the Bitterroot River. This area is just across the Continental Divide from the Big Hole Basin. The white trees are insect-killed, the foliage being red at the time the picture was taken. The remaining green trees are Douglas fir."



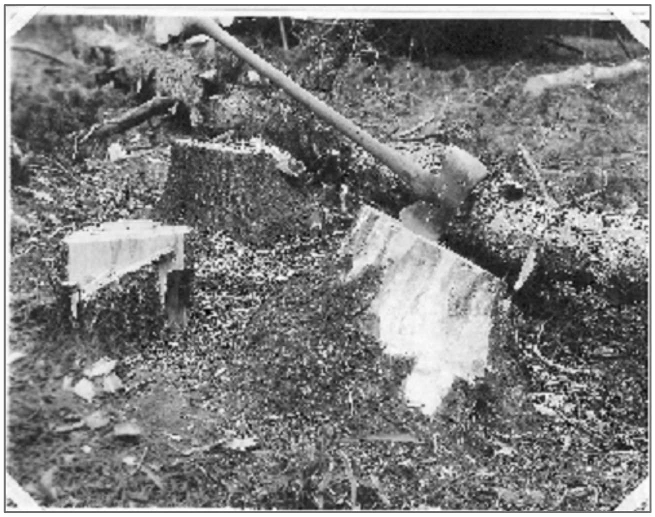
Picture 2. "Mountain pine beetle infestation in the lodgepole pine stands on the East Fork of the Bitterroot River. This area is just across the Continental Divide from the Big Hole Basin. The white trees are insect-killed, the foliage being red at the time the picture was taken. Many trees can be seen from which the foliage has fallen. The red tops (white trees) represent the 1926 attack."



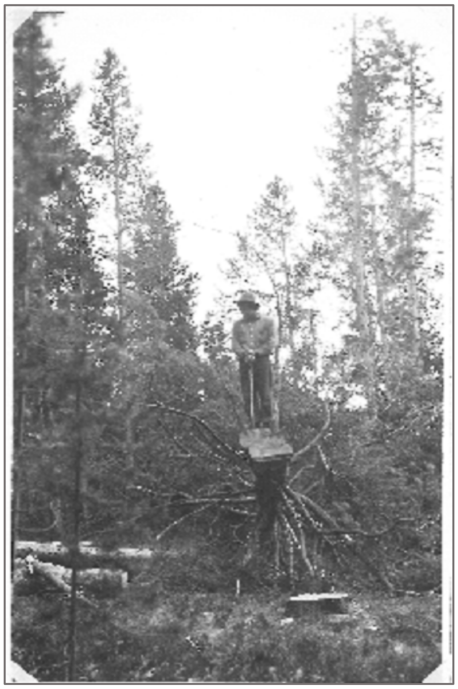
Picture 3. "The infested trees are located and tagged by the spotters. These tags carry the spotting crew symbol, the tree number, and a space for the stump diameter and the length. The spotter places his initials in the lower right-hand corner."

Picture 4. “The control crews fell the trees.”

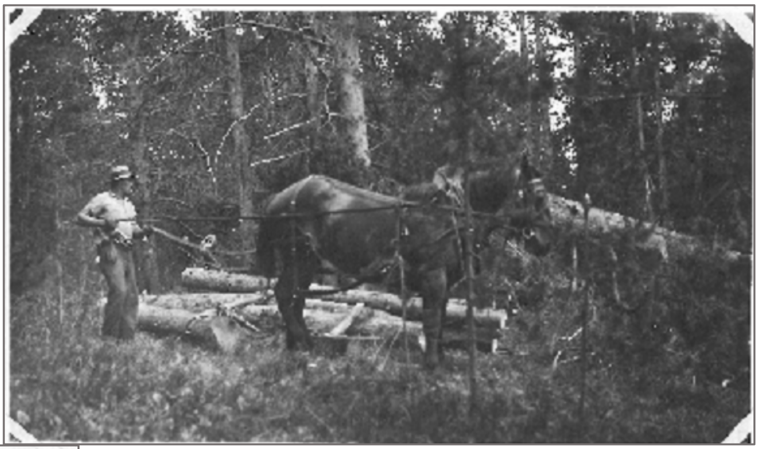
Picture 5. “The infested bole is cut in 12- to 16-foot lengths so that they can be easily handled.”



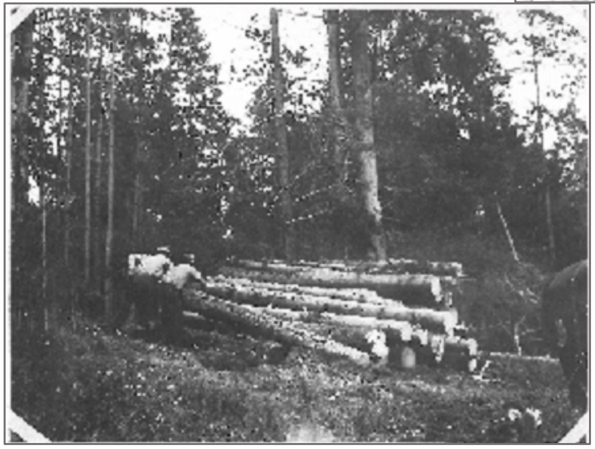
Picture 6. “The stumps are only 5-6 inches in height. Very little infestation is left on these low stumps and it is not necessary to peel them. This stump has been peeled to show the green cambium.”



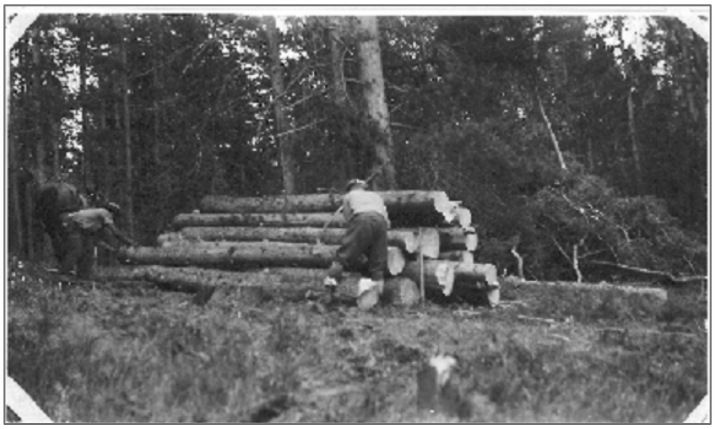
Picture 7. “The trees on the edge of the timber stands and around parks and openings are low, scrubby individuals, which are hard to bundle. It is more economical to burn these trees standing whenever possible. Some of these trees have limbs that are infested and which require a horse to skid them to the decks.”



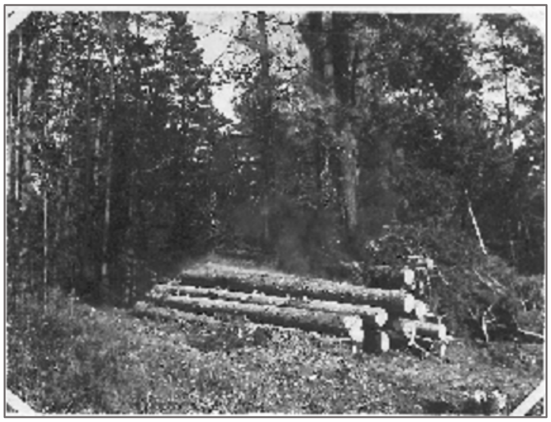
Picture 8. “The logs are skidded with a horse to the decks.”



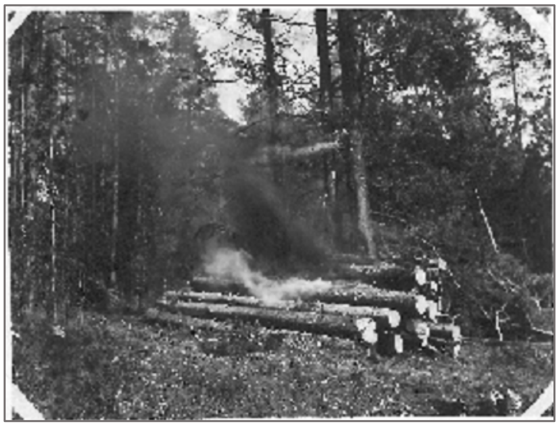
Picture 9. “The logs are decked. The size of these decks varies with the number of infested trees within the group. Quite often these decks are built against infested trees.”



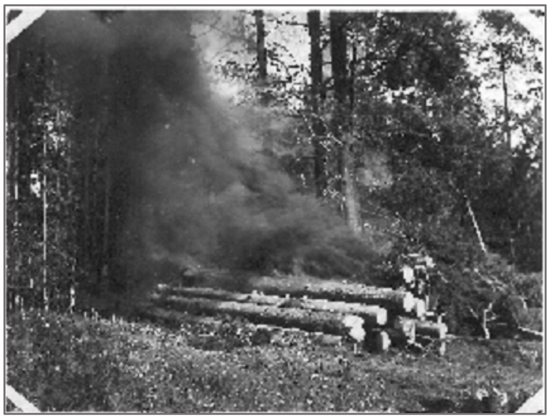
Picture 10. “Most of the logs are light and can be easily handled by two men.”



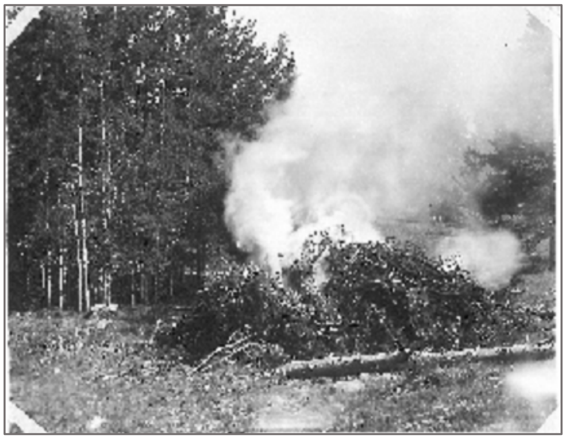
Picture 11. “The log decks are burned. Fires are started on the windward side.”



Picture 12. “In dry weather the brush is not burned on the decks.”



Picture 13. “For an hour or two the decks make a very hot fire.”



Picture 14. “When possible brush is piled on the log decks and burned with the logs.”

Picture 15. “It is only during the latter part of the season that the brush cannot be burned on the decks.”

Picture 16. “A burning log deck covered with brush.”

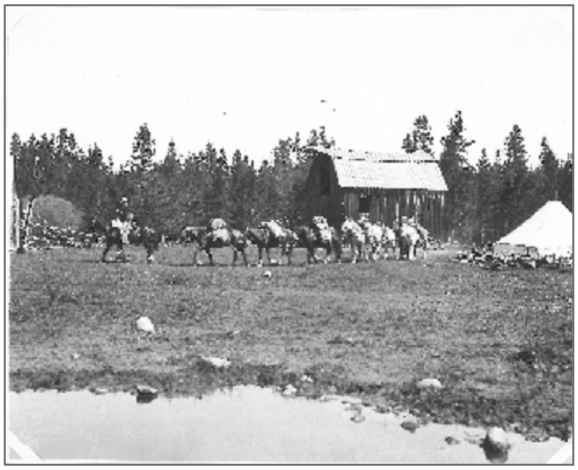
Picture 17. “A burned log deck.”

Picture 18. "Burning a standing infested tree."

Picture 19. "Infested trees which have been burned standing."

Picture 20. "*Dendroctonus* Avenue. Headquarters Camp."

Picture 21. "Breaking camp."



Picture 22. "Pack string."

Picture 23. "Motor transportation."